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Metal Work and Electric Wiring

379 Illustrations

By
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SHEET-METAL WORK
ORNAMENTAL METAL WORK
ELECTRIC WIRING

Published by
INTERNATIONAL TEXTBOOK COMPANY
SCRANTON, PA.
1928

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PREFACE

The volumes of the International Library of Technology are made up of Instruction Papers, or Sections, comprising the various courses of instruction for students of the International Correspondence Schools. The original manuscripts are prepared by persons thoroughly qualified both technically and by experience to write with authority, and in many cases they are regularly employed elsewhere in practical work as experts. The manuscripts are then carefully edited to make them suitable for correspondence instruction. The Instruction Papers are written clearly and in the simplest language possible, so as to make them readily understood by all students. Necessary technical expressions are clearly explained when introduced.

The great majority of our students wish to prepare themselves for advancement in their vocations or to qualify for more congenial occupations. Usually they are employed and able to devote only a few hours a day to study. Therefore every effort must be made to give them practical and accurate information in clear and concise form and to make this information include all of the essentials but none of the non-essentials. To make the text clear, illustrations are used freely. These illustrations are especially made by our own Illustrating Department in order to adapt them fully to the requirements of the text.

In the table of contents that immediately follows are given the titles of the Sections included in this volume, and under each title are listed the main topics discussed.

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SHEET-METAL WORK

USES OF SHEET METAL

1. The greater part of sheet-metal work used in building construction is employed for the following purposes:

1. For covering and flashing roofs and their intersections so that the roofs may conveniently be made water-tight.

2. For wall covering and the formation of columns, cornices, balustrades, and string and molded courses. In some cases, the entire outer surface of the walls of a building is covered with sheet metal, the material being made to resemble masonry or brickwork, an effect produced at low cost. Frame buildings may also be covered with sheet metal in order to render them less liable to fire from adjacent structures.

3. In forming gutters, valleys, or other water channels that are graded down to certain points of outlet, so that the rain that falls on the roof may be conveniently drained away, thus preventing the roof water from being shed on the ground around the building.

4. For conductor pipes, sometimes called leader pipes, which are commonly secured against the outside walls of a building to connect the lowest points of the roof gutters with an underground drainage system, or simply to a drainage above the surface of the ground, so that the roof water may flow freely away from the gutter.

5. For covering domes and lanterns, and in forming crestings and finials.

6. For interior decorations, such as the covering of walls and ceilings where first cost is an important factor; or, for

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the covering or formation of the inside trim, doors, windows, casings, etc.

7. For flues and other conduits commonly employed for purposes of ventilation.

While there are other positions and features where sheet metal may be employed, a thorough knowledge of the foregoing should enable any one to reason out and solve any special problem that may present itself.

EXTERIOR SHEET-METAL WORK

INTRODUCTION

2. The general subject of sheet-metal work for roof coverings, flashings, etc., is treated in *Roofing*, consequently, this portion of the subject will not be considered in this Section.

The kind and class of exterior sheet-metal work required will of course depend on the character and purpose of the building. Mills, factories, workshops, warehouses, etc. are often covered with galvanized sheet iron in the plainest possible manner, with no pretensions to artistic treatment, while store and office fronts are often covered with sheet metal bent and formed into elaborate moldings, or pressed and stamped into ornamental details, which are grouped so as to form decorative features.

3. Generally speaking, sheet-metal coverings for buildings are imitations of brickwork or masonry, and when properly arranged and attached to a good solid backing and carefully painted, they make, for some time, successful deceptions.

Sheet-metal fronts and other wall coverings are employed only when the desire for ornamentation exceeds the owner's willingness or capability to pay for the genuine article. From a speculative point of view, they may be paying investments, provided that the metal is protected against corrosion; but from an architectural or engineering standpoint they are utter failures.

WALL COVERINGS

4. Wall coverings may be classed as plain and ornamental. Plain wall coverings are used chiefly on buildings intended for manufacturing purposes and for such structures as are erected for temporary use; while ornamental coverings are generally used on the fronts of cheap city buildings, such as warehouses, stores, theater fronts, etc.

5. The sheet metal employed for wall coverings is usually galvanized sheet iron or steel, the sheets being either *plain*, *crimped*, or *corrugated*.

Plain sheet iron is seldom used except for the most ordinary work, where appearance is not at all considered. The sheets are simply nailed to a backing of matched lining or ordinary sheathing, the object usually being to prevent the building from readily becoming ignited, should an adjacent building be on fire.

The chief objection to plain sheet-iron siding is that the metal will bulge and become distorted in many ways, until the whole side of the building will actually appear to be covered with large blisters.

6. Crimped sheet iron is superior to plain sheet iron for covering large flat surfaces, because the crimping helps to prevent the sheets from bulging, and thus, to a certain extent, avoids the blistered appearance so pronounced on plain sheet-iron siding. A clipping of crimped sheet metal is shown in Fig. 1. The sheet is crimped by being passed through ribbed or roughened rollers, which give it the appearance of being slightly corrugated. Crimping the sheets makes them stiffer than they would otherwise be. The sheets can be bent to any desired angle without breaking the material, which is impossible with corrugated iron. Beside being used as a wall covering crimped iron can be used for cornices, door and window casings, friezes and panels.

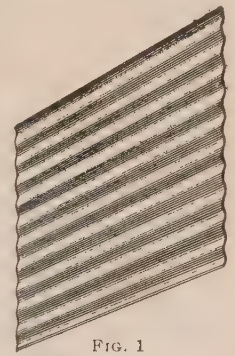


FIG. 1

Crimped sheets may be nailed to furring strips, or to studs or posts set at from 12 to 16 inches between centers, provided that the grooves run at right angles to the strips or studs. Thus, if furring strips were nailed on the studding, the grooves would be vertical; but if the sheets were nailed directly on the studding, the grooves would be horizontal. It is best, however, in every case to provide a solid flat backing for crimped sheet-metal work.

7. Corrugated sheet iron is preferable for siding where there is an extensive, unbroken surface. The corrugations not only strengthen the sheets, and thus enable them to be attached to furring strips as far apart as 4 feet, but they also relieve, by the play of light and shade, the monotony incident to a flat surface.

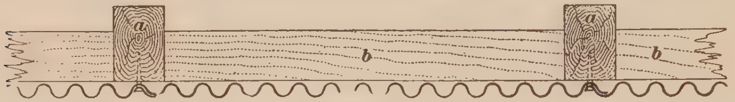


FIG. 2

Corrugated sheet iron should always be fastened with the corrugations running vertically, not so much for appearance as to obtain a perfectly water-tight siding with ordinary lap joints. Fig. 2 shows the method of forming vertical joints. The corrugations are simply lapped and the two sheets are nailed to the posts, or studs, *a*, *a* with flathead, galvanized-iron nails, as shown in the illustration. The top edge of each sheet is nailed to cross-pieces—sometimes called "nailers"—*b*, *b* that are spiked or framed in between the posts. The horizontal joints of the sheets are lapped as shown in Fig. 3; cleats are riveted on as shown at *a*, to bind the lower end of the sheet so as to make a close joint and also allow for

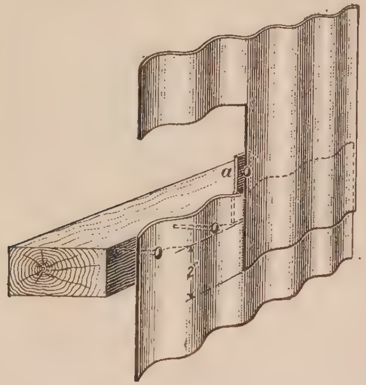


FIG. 3

expansion and contraction of the sheets. The top sheet should lap over the nails at least 2 inches.

Corrugated-iron sheets are often fastened to sheathed walls, and the common practice is to nail them all around the edges, but, in this case, expansion and contraction soon loosen the sheets either by drawing the nails or by tearing the nail holes. The plan of attachment just described, and illustrated in Fig. 3, is to be recommended even when the sheets are fastened to a flat surface.

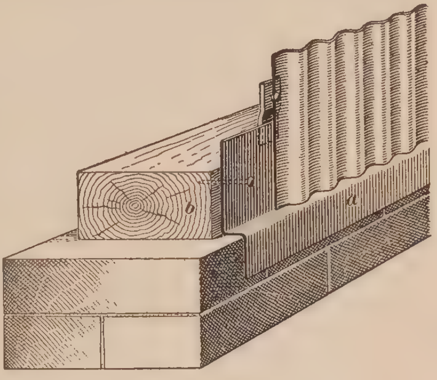


Fig. 4

8. Fig. 4 shows how the corrugated sheets may be put on at the base of the framework. A *base strip a*, made in the form of an offset, is securely nailed to the wooden sill *b*, the strip being flanged so that it may cover the exposed portion of the wall. The sheets are clamped to the top edge of this strip with cleats 1 inch wide by $\frac{1}{8}$ inch thick, similar to that shown in Fig. 3.

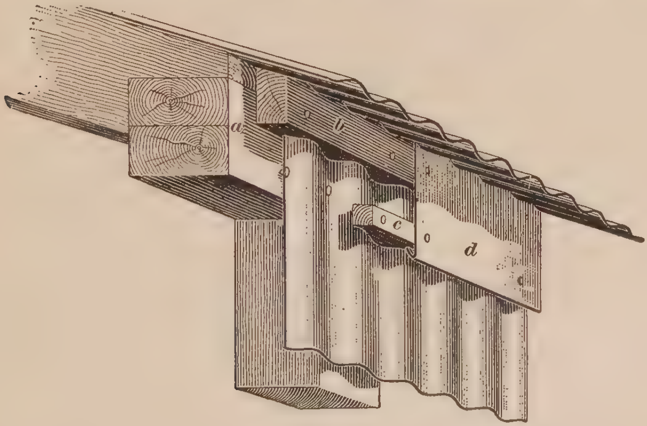


Fig. 5

9. Fig. 5 shows how the sheets are finished at the eaves. The top edges of the sheets are nailed to the plate *a*. A strip of wood *b* about $1\frac{1}{4}$ inches thick, cut on one edge to fit the profile of the corrugations of the roof, is nailed to the upper edge of the plate above the sheets, and another strip *c* of the same material is nailed to the lower edge of the plate. A facia of crimped sheet iron *d* covers both strips and forms a drip at its lower edge, as shown. This arrangement makes a neat, water-tight, and wind-proof connection between the siding and the roof.

10. Fig. 6 shows the finish at the corners of the building; this makes a water-tight junction and presents a neat appearance. Since the corrugated iron is laid against the framework, it is necessary to nail $\frac{7}{8}$-inch wooden strips on the outer faces of the corner post *a*. The corrugated iron butts against the edges of these strips, and a crimped sheet-iron corner piece is sprung over and locked into the corrugated wall sheet, as shown.

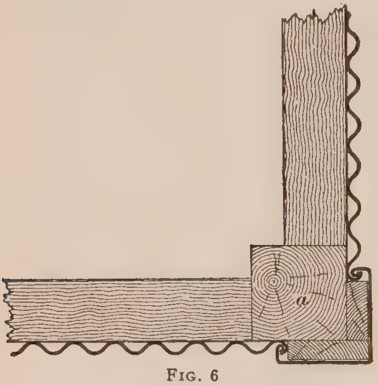


Fig. 6

This arrangement can also be used around any window or door opening. The arrangement shown in Fig. 4 may also be used over the lintels of any door or window opening.

11. Corrugations in common use measure about $2\frac{1}{2}$ inches, from center to center, and are about $\frac{3}{4}$ inch deep.

Black corrugated iron should always be painted with the best quality of metallic paint before it is secured in place.

12. **Stamped siding** is most commonly employed for covering large flat surfaces of outer walls, the sheets being pressed to such a shape that they resemble *rock-faced*, or *tooled*, stonework or brickwork. This siding is stamped in plates 10 feet long by 2 feet wide, and the plates are sold by the lineal foot. Like crimped sheet metal, it is nailed to furring strips, to ordinary sheathing, or to brick walls, the vertical joints being lapped and closely nailed.

Particular care should be taken to lap all the vertical joints in sheet-metal work, so that the heaviest rain storms will blow with the laps and not against them. It is noticeable in nearly every district that the strongest winds and greatest rain storms nearly always blow from certain directions; these directions should be determined, and the sheet-metal work should be arranged to prevent the rain from blowing into the seams.

Brick walls should always be thoroughly furred to receive the sheet-metal work. It is a mistake to suppose that sheet-metal work can be securely nailed into the joints, because expansion and contraction will very soon loosen the fastenings.

CORNICES

13. Sheet-metal cornices are made in such a variety of patterns, in such a wide range of sizes, and are required to be placed in such a diversity of situations, that there must be a great variation in the methods of construction. Very many designs, however, correspond as far as having moldings continuous throughout their lengths. All are supported by projecting brackets or lookouts. The joints, shape, and material of the cornice proper, and the construction of lookouts, are the particular features in cornice work that will be considered here.

As a rule, cornices are made at the cornice factory, according to drawings and specifications, and are shipped in parts to the building.

Brackets, modillions, dentils, etc. are usually secured to the cornice at the factory. Trusses and check, or stop, blocks are shipped in separate packages. Thus it will be seen that the cornice setter or tinsmith is only required to assemble the several parts and erect them in place on proper supports. The supports in general use are wood or iron, the latter being employed in the better class of buildings.

14. Cornice Erection on Wooden Supports.—In Fig. 7 are shown the parts and joints of a sheet-metal cornice as ordinarily constructed in small sections on a brick wall. The foot-molding *a* is fastened to, and supported by, a board and wooden lookouts, the lower member being allowed to hang down below the reglet, or groove, that runs along the joint of the brickwork at the under side of the lookouts. The top of the foot-molding enters the reglet in the next joint above. The paneled frieze *b*, between the trusses, or brackets, *c*, is made up in one piece, the edges being doubled over and secured into reglets as shown. The modillion course, which generally includes the small moldings above and below the plain surface from which the modillions project, is attached to the brickwork in a similar manner and is secured in place with a long, narrow, metallic wedge. If the cornice is erected while the walls are being built, the upper flange of each piece is usually bent over far enough to be safely bedded in, the lower edge of the sheet above being bent over and pushed into the same joint as the work progresses. The soffit *e* may be bent up out of the same piece

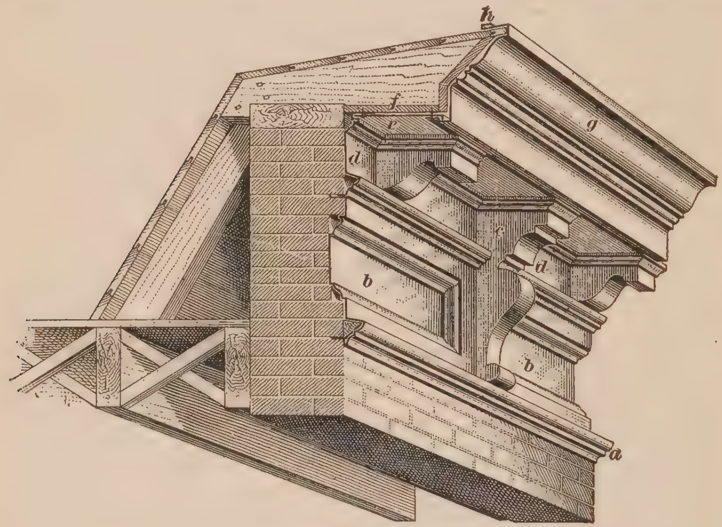


FIG. 7

with the bracket molding. The drawing, however, shows it separate, and secured to the board lining *f*.

The *crown molding g* is bent over the top of the roof boards, leaving an edge turned up, as at *h*, for easy connection to the sheet metal of the roof. The lower edge of the crown molding should be made to form a drip, as shown, and should be securely nailed to the board lining *f*.

The brackets and trusses, which are hollow and built up from stamped sheet metal, are riveted and soldered in position. It is difficult, however, to properly attach them when the cornice is put up in sections, as shown, so it is advisable to have these projections riveted and soldered on before the cornice is erected. In the construction of cornices, particular care must be taken to avoid pockets in which water may accumulate. If it is suspected that a water-tight pocket exists, a small hole should be punched at the lowest point to allow any water to drain out. If this is not attended to, these pockets may fill with water, freeze, and burst.

15. Another plan for fastening cornices to brick walls is to spike boards against the face of the walls, put the cornice on top of the boards, and nail it in place. The former method, however, is preferable, not only because the nails will show by the latter method, but chiefly because the boards are likely to warp and consequently cause the cornice to become distorted and loosened.

The cornice work shown in Fig. 7 is attached to a brick building with a flat roof. The roof pitches down to the back of the building and the conductor pipes, of course, are in the rear. When the roof pitches in the direction of the cornice, a gutter is usually formed at the back of the crown molding.

16. Iron Supports.—It is comparatively easy to fasten a sheet-metal cornice to a wooden building, or even to woodwork that is spiked to brick buildings; but it is considerably more difficult to properly fasten a cornice to brick, stone, terra cotta, or to the structural ironwork of modern fireproof buildings.

Fig. 8 shows a system of bracing well adapted for a cornice at the top of a brick wall. The framework or bracing shown, which is mostly composed of angle irons, should be built into the wall. These frames should be placed from 2 to 4 feet apart, according to the projection of the cornice. The cornice is sometimes bolted to the framework after the wall is finished.

The strongest and best plan, however, is to attach the iron frames to sections of the cornice that are about 14 feet long, hoist these sections, and set them on the wall when it has been leveled to the required height, as at *a*. When lined up and in proper position, the frames are tied temporarily in place to keep the cornice from toppling over until the brickwork *b*, *b* is all filled in and has set. This mass of brickwork must be sufficient to more than counterbalance the weight of the cornice. If there is any danger of the cornice being too heavy for the counterweight, the legs *c* must each be tied separately to some beam or other rigid part of the building.

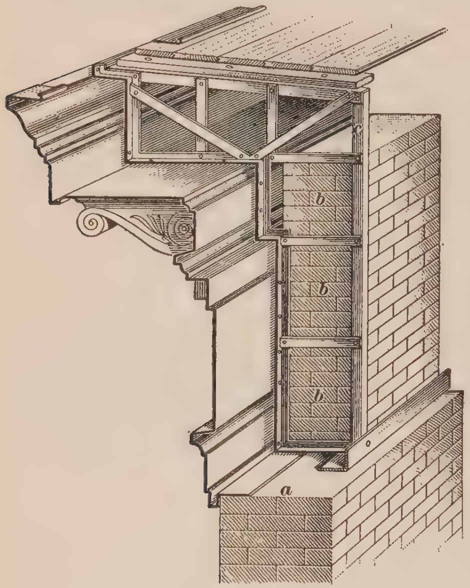


FIG. 8

There are, of course, many kinds of iron supports for cornices other than that shown in Fig. 8, but, with a little judgment, a lookout for any position can be designed. The principal points to be considered in such a design are: (1) to obtain a band of iron that will follow, in a general way, the contour of the cornice; (2) a means of bracing this iron band

and preventing it from changing its shape; (3) a means of rigidly securing the iron band to the building, iron beams, or columns, being preferable for anchoring points.

17. Joints in Cornices.—Different mechanics have different methods of making vertical joints in cornices; some of these are very neat, strong, and durable, while others should not be tolerated. The only two joints worthy of mention here are the *butt joint* and the *lap joint.*

18. A **butt joint** is shown in Fig. 9. The edges of the sheets *a*, *a* that form the cornice are trimmed perfectly square and straight, so that when brought together they will fit closely. A strap *b*, which is made from the same metal as the cornice, is then riveted the entire length of the vertical seam, and its edges are soldered to the back of the cornice, as shown. The rivet heads are all on the outside, and the process of riveting draws in the heads and makes them scarcely visible. The rivets should be as close together as possible.

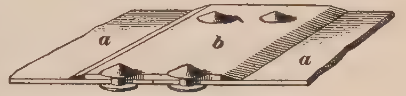


FIG. 9

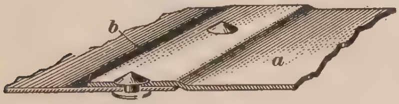


FIG. 10

Fig. 10 shows a **lap joint.** The sheets are lapped over each other a distance of 1¼ inches and then riveted closely. The back sheet *a* is dressed forwards to be flush with the other, as shown, and the back edge is then soldered, as at *b*.

19. Both of these joints are strong and durable. The butt joint, however, is neater than the lap joint. A first-class mechanic can make one of these joints so that a perfectly smooth surface will be obtained.

The *rivets* for galvanized-iron cornices should weigh 1½ pounds per thousand, for Nos. 24, 26, 28, and 30 sheet iron. The rivets for copper cornice work should weigh 1 pound per thousand.

20. **Cornice seams,** or horizontal joints, are also made in a variety of ways, but the following methods illustrate good practice when the joints must be made on the job.

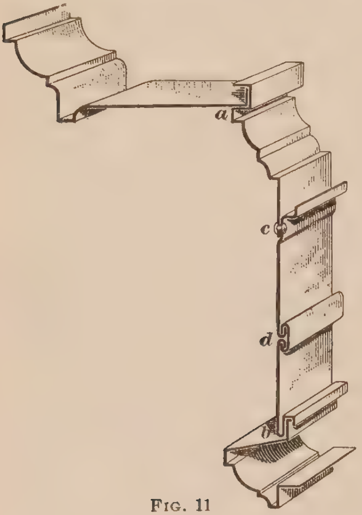


FIG. 11

Cup joints are shown at *a* and *b*, Fig. 11. The position of the copper in these joints shows how they appear when the cornice is being fitted up. After the cornice is lined up in place and the vertical joints are all made, the edges are bent over twice, thereby locking the seams. These joints are necessary only in large cornices.

When a seam must be made on a flat surface, such as on a wide frieze, either of the methods shown at *c* or *d* may be employed. The seam at *c* is lapped and riveted like that shown in Fig. 10; a stiffener, however, is bent at the back to keep the seam straight. This is the stronger seam of the two. It is preferable to that shown at *d* in places where rain will wash over it. When it is desired to form a very close horizontal joint, the *clinch seam* at *d* may be used. The edges of the sheets are bent over and butted together in position. A cap is then slipped over the seam as shown. When the work is all lined up, the seam is closed by flattening down the cap. This process draws the sheets together and makes a very close seam.

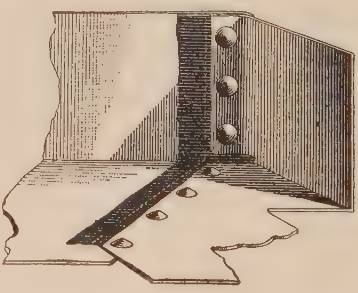


FIG. 12

21. **Miters.**—All miters in cornice work, pediments, and elsewhere may be classed as *lap miters* or *butt miters.*

Outside miters are made in different ways, but there are only two reliable methods. The first, or lap miter, is made by returning a $\frac{1}{2}$-inch flange on the inside of the miter, as shown in Fig. 12. This flange must be riveted closely and soldered on the inside. The chief objection to this miter is that the edge of the sheet is visible.

To make a close miter, it is necessary to bevel and butt the edges as shown in the butt miter, Fig. 13. In this figure, the edges of the copper are fitted closely together. A copper angle strap *a* is then riveted and soldered securely in the inside angle the full depth of the cornice. A few gussets are then riveted and soldered across the inner corners as shown. These gussets help to keep the cornice square during shipment and prevent the edges from being pulled apart by expansion and contraction. The method shown in Fig. 13 should be used on all first-class work.

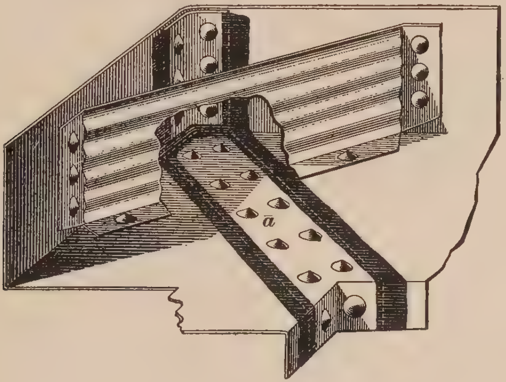


FIG. 13

Inside miters are made and reinforced in a similar manner, but owing to the fact that gussets cannot be used, it is advisable to rivet a reinforcing angle strap over the $\frac{1}{2}$-inch flange.

22. Iron-Beam Cornices.—In some buildings, the ironwork of the first story or "store front" does not project beyond the wall; and the iron beams, such as those over store windows, often require to be covered with a metal panel or cornice, or both combined.

Fig. 14 shows a *panel course* attached to an iron I beam. A series of bar-iron braces *a* are secured to the web of the I beam and the panels are fastened to them with countersunk screws, so that the heads will finish flush with the face of the panel. A rabbet is formed at *b* to cover the joint between the top of the window frame and the iron beam. When the beams are in place, and before the brickwork *c* is built thereon, the sheet-metal panel course is pushed over the face of the beam and doubled over at the back edge of the upper and lower flanges, as shown at *d*. The braces *a* thus merely support the frieze and prevent it from sagging. If desired, a plank instead of iron straps may be bolted to the web of the beam to support the panels.

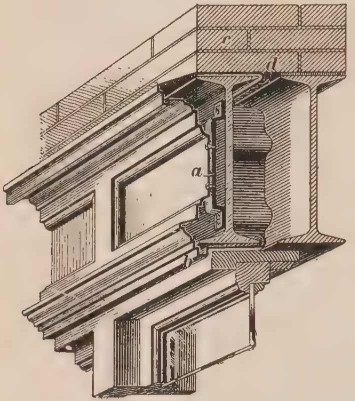


FIG. 14

23. String-Course Cornice.—A string-course cornice, or store cornice as it is often called because it is so commonly used over store fronts, is shown in Fig. 15. The lookouts are made of band iron $\frac{1}{4}$ in. × $1\frac{1}{2}$ in. and are tied into the brickwork at *a* and *b*, these ends being built into the wall. The lower ends of the lookout frames are continued down over the face of the beams and along under their lower flanges, and are then bent up at the back, as shown at *c*. An angle iron running the whole length of the cornice is bolted to the ends as shown at *d* and keeps them in place. A sloping platform of matched boards is screwed on the top of the lookouts. The sheet-metal work is bolted to the band iron in the usual manner, a soldered double seam with cleats is made at *e*, and the top covering enters the wall at *f*. An iron plate, either plain or ornamental, is usually secured at *g* to form the soffit of the beams over the opening.

After the beams are set on their columns, and before the mason begins to build on them, the cornice must be set in position. The cornice being set true and level, the mason finishes the wall up to the course *h*; then the flashing is put on, the top edge *f* being bent over about 3 or 4 inches, as shown. When this is finished, the mason proceeds to build the superstructure. If the wall is built before the cornice lookouts are ready, the anchors *a* and *b* must pass through the wall and be bent over at the back, and the flashing *f* must be let into the reglet and be batted with lead, the reglet being filled with mastic or other cement in the usual manner.

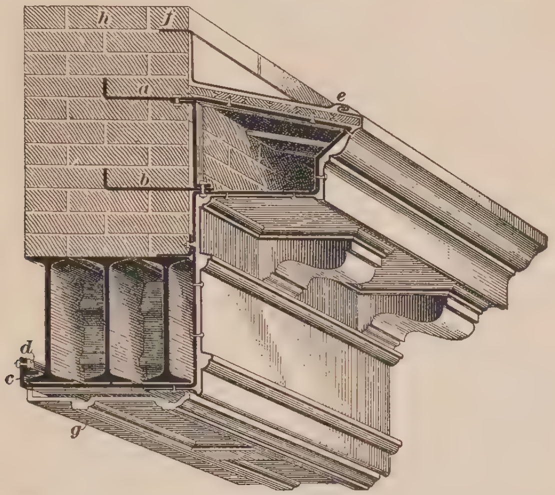


FIG. 15

24. In many cases, it is advisable to make the lookouts of cast iron instead of wrought iron, as, for example, when a very large number of small lookouts having the same shape are required. If the molding is small and extends as a belt, or string-course, around the building, it is certainly advisable to use cast-iron lookouts. The chief advantages of cast-iron lookouts are accuracy in the lines of the cornice, economy in construction, and durability.

Accuracy is insured when the cast-iron lookouts are properly lined up, because each lookout is a duplicate of the others, all of them being cast from the same pattern. Economy of construction lies in the fact that the labor of making the lookouts and of fitting the sheet metal to them is reduced to a minimum; and the durability lies in the fact that cast iron is less corrosive than wrought iron. Iron lookouts should always be coated with asphalt or other protective covering in order to prevent rapid corrosion.

25. Metals Used for Cornices.—Galvanized iron is commonly used for the cornices of ordinary buildings, and should be painted on both sides to protect it from corrosion. Sheet copper (cold-rolled) is preferable, however, in every case. The metal itself costs considerably more than iron, but the labor and other expenses relative to its construction and installation are about the same.

26. Copper cornice work does not require to be painted for protection. It is, in fact, better practice to leave the metal thoroughly scoured, clean, and uncovered, and allow the weather to slowly change its color. Copper sheet-metal work has naturally a dark-green tint, but it often takes a very long time to get that color. The time required depends considerably on the climate, the weather, and the composition of the atmosphere. Where the rain becomes acidified by falling through air charged with sulphurous gases, the color changes rapidly, but where it falls pure and clear, the copper changes color very slowly.

When it is desired to hasten the color, it is customary to produce an *artificial* color by washing the copper with acids. One method is to thoroughly scour all the copper work to remove any grease or acid spots, then wash the entire surface with a solution composed of 1 pound of sal ammoniac to 5 gallons of water. This solution should stand about 24 hours before it is applied. After the copper has been uniformly covered with the solution, it should be allowed to stand for a day or two and should then be lightly sprinkled with clean water. If the water is put on too freely, it will run in streaks. After a few days the copper work should have a beautiful and uniform greenish-brown color that will stand the weather. The same effect may be produced by using vinegar and salt in the proportion of ½ pound of salt to about 2 gallons of vinegar.

27. **Soldered Seams.**—Although it is advisable in all sheet-copper work to solder the seams on the back where they cannot be seen, it nevertheless often happens that some parts must be soldered on the front. The solder does not change color like the copper, and, consequently, when not properly treated, such seams tend to spoil the appearance of the work.

To give solder a copper color, it is necessary to deposit a copper plating on it. This is accomplished by first thoroughly scouring the seams, and then washing them with a solution of *sulphate of copper* and water. The solution should be strong. When applied with a brush to the solder, a film, or plating, of metallic copper is immediately formed over the solder, and by repeated applications a fairly substantial coating of copper is obtained.

WINDOW SILLS, LINTELS, AND CAPS

28. **Window sills** are made of sheet metal to represent cut-stone sills. They should be filled in behind with timber of the proper size. The metal sills are usually slipped over the wood backing and are fastened to the wall by nailing closely through the flange *a*, Fig. 16, which extends along the bottom and up the sides. The top flange *b* is made wider than that at *a*; it is nailed against the window frame, and is bedded in white or red lead to make it watertight. A better plan, however, is to bed the window frame over the metal sill with red or white lead, the metal being flanged and passing up

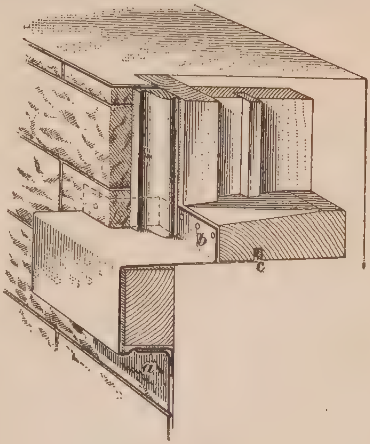


FIG. 16

into the groove *c*. Metal window sills are generally used on galvanized-iron fronts. Copper is seldom used for this work.

29. Window lintels are covered in a similar manner, the chief difference being that the top flange of the lintel is overlapped by the metal siding above it. The soffit of the lintel flanges down against the top of the window frame and is nailed to it. Particular care, however, should be taken to have a well-inclined wash on the lintel. Horizontal surfaces, particularly pocketed surfaces, are very objectionable and should always be avoided.

30. The covering of bay windows, architraves, pediments, etc. depends altogether on the design. An important point to be considered in the line of sheet-metal work for bay windows, pediments, etc., is the provision for lookouts and other projections to which the cornice and other moldings must be attached. Small moldings are usually placed on the flat sheathed surfaces, while lookouts are required for cornices and other large projections. It is advisable, in all the work, to provide solid backing for the sheet metal. When wooden lookouts are used, they should be so made that the metal work can be nailed across the grain of the wood, not with it. The expansion and contraction of the metal soon draws out and loosens all nails driven in the direction of the grain.

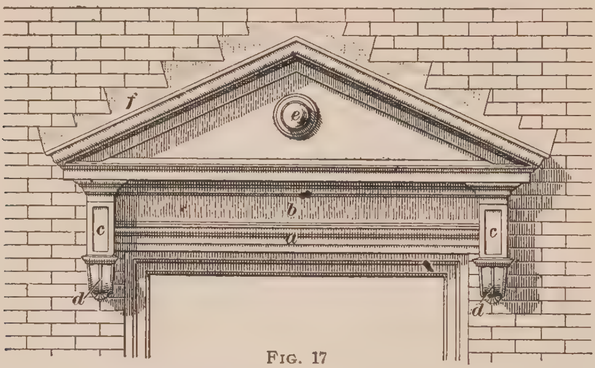


FIG. 17

31. Window caps, like all other ornamental parts of sheet-metal work, are made up from stock sizes and shapes of bent or stamped sheet metal. Fig. 17 shows a sheet-metal window composed of an architrave *a*, a frieze *b*, and two impost blocks *c*, *c* supported by brackets, or trusses, *d*, *d*. The impost blocks support the pediment *e*, and a counter-flashing at *f* against the brick wall makes the top water-tight. If the cap is put on after the walls are built, it is customary to fasten it in place against wooden lookouts, as shown at *b*, Fig. 18. Furring strips *a*, *a* are nailed to soft-pine plugs, previously driven into the wall, and the lookouts *b* are set about 1 foot apart along the line of the furring strips and nailed to them. Two special lookouts are to support the trusses. The sheet-metal cap is then set over these lookouts and is rigidly nailed to them. The metal is extended under the soffit of the lintels and flanged down against the hanging tile of the window frame, and is neatly finished with an angle molding bedded in white lead and well nailed in place. The wash *c* of the cornice is turned up against the wall and is counterflashed in the usual manner.

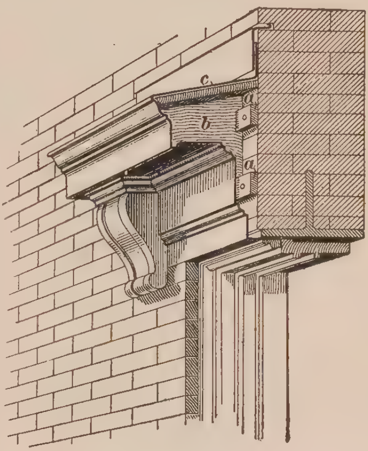
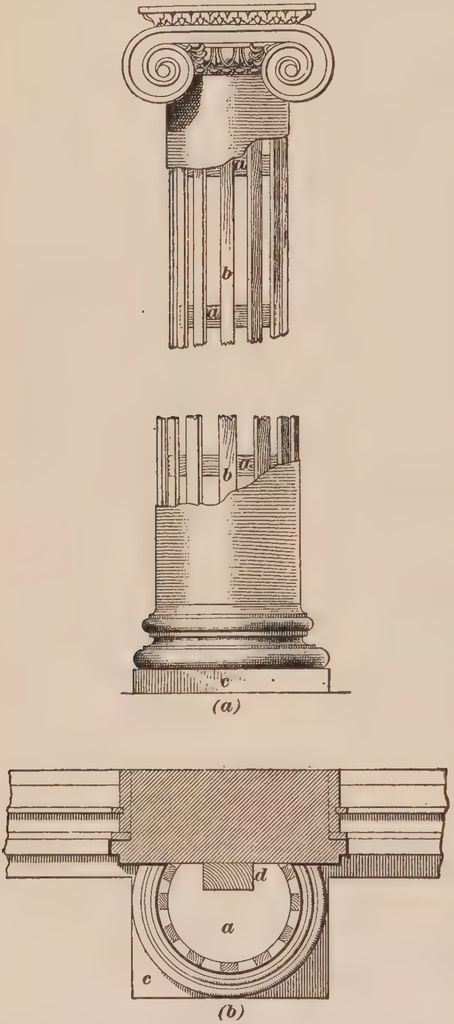


FIG. 18

If the wall has not been built, it is advisable to use iron lookouts and build them in the brickwork when the wall has been brought up to the proper height. The upper surface of all window caps, sills, and cornices should be carefully protected during the erection of the building. Every window cap, and indeed every other projecting molding or cornice, should be closed water-tight on top with a sloping deck, or wash, and should be sufficiently strong to sustain the weight of a man.

COLUMNS

32. There are many kinds of columns and pilasters, and different methods of constructing them. In a general way, however, Fig. 19 illustrates common practice. This figure shows in elevation at (*a*), and in section at (*b*), a three-quarter column, such as is used for the front of a building. The column is braced by wooden blocking, which is composed of 1½- or 2-inch horizontal blocks *a*, *a* that are spiked to an upright post *d* and spaced at intervals of not more than 2 feet. Vertical strips *b*, *b* are nailed to the face of the blocks, and are run from the square plinth *c* to the top of the capital. The sheet metal that forms the column is continued down to the plinth, and up to the block or other member over the capital, the seam on *c* being soldered water-tight. The back edges of the sheet are nailed to the face of the wall in the regular manner. The base is then put in place and



(a)

(b)

Fig. 19

soldered to the column, after which the capital should be soldered to the column. This is one of the best methods of bracing sheet-metal columns.

The same method is employed in fireproof construction, except that iron is used instead of wood. Pilasters are formed and covered in the same manner as columns. In all column and pilaster construction, the formation of pockets wherein water may accumulate should be avoided.

FIRE-DOORS AND FIRE-SHUTTERS

33. Wooden fire-doors may be covered with any kind of sheet metal that has a high temperature of fusion. Copper and zinc are not suitable for this work; galvanized iron and tin are therefore used, though tin seems to have the preference. The covering is generally put on as follows: The outer edges of the door are covered first with a strip of tin, which is returned over both faces to a distance of about 6 inches, the edges being nailed to the woodwork and turned over, as shown in Fig. 20. The flat part of the door is then covered with sheets 14 in. × 20 in., in a manner similar to that employed on flat roofing. This arrangement avoids seams around the edges of the door, and allows it to shut with a close contact. A heavy body metal should be employed for this work, because the efficiency of the covering in case of fire depends on the thickness of the metal, and not on the thickness or quality of the protecting coat. The seams should all be closely nailed, and then locked and

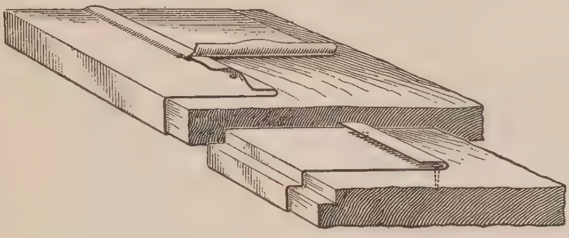


FIG. 20

thoroughly pounded down. A layer of asbestos cloth should be placed between the tin and the wood.

Corrugated-iron doors and **shutters** are also extensively used, but they do not form as efficient fire-stops as ordinary wooden doors or shutters that are properly covered with tin and asbestos. The corrugated iron must be thoroughly braced with an angle-iron or **T**-iron frame.

The greatest objection to iron fire-doors and fire-shutters is that they warp very easily when attacked by flames. Plain iron warps so much that it is practically useless as a fire-stop. Fig. 21 furnishes a good illustration of this. The door shown is composed of one sheet of thick metal, and is provided with iron cross-pieces to which the hinges are riveted. The fire plays against the inside of the door and warps the sheet outwards, thus allowing an opening for the flames, as shown.

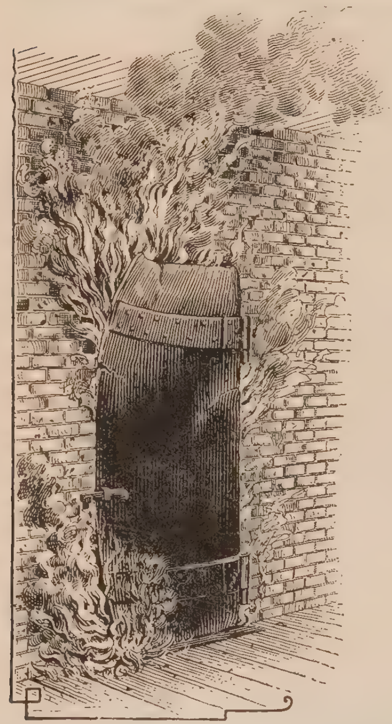


FIG. 21

COPINGS

34. Wall Copings.—The tops of all brick walls must be made waterproof, otherwise rain will soak into the wall heads and ultimately ruin them. When cheap, light coping stones are used, it is necessary to lay a sheet of metal (preferably lead or copper) under them, as shown in Fig. 22. The sheet metal is simply laid on the brickwork and bent over about 1 or 2 inches at each edge. The stones are then bedded in place in the usual manner.

35. Coping Blocks.—When coping blocks are used to surmount cornices, the flashing or wash of the crown may be extended through to the back of the wall, where it may connect to the roof covering, or to a gutter lining, as the case may be. When it is necessary, however, to entirely cover the blocking course with the same kind of metal as the cornice, the metal work of the cornice may be extended up and continued over the blocking course, as shown in Fig. 23, the sheets being crimped and held in place by cleats in the seams *a*, *b*, and *c*. A wooden wall cap is placed on top of the brickwork to protect the top course and to take the cleat nails.

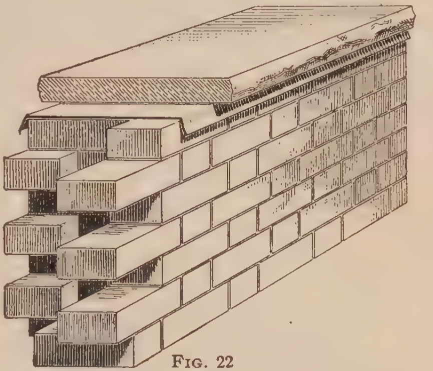


FIG. 22

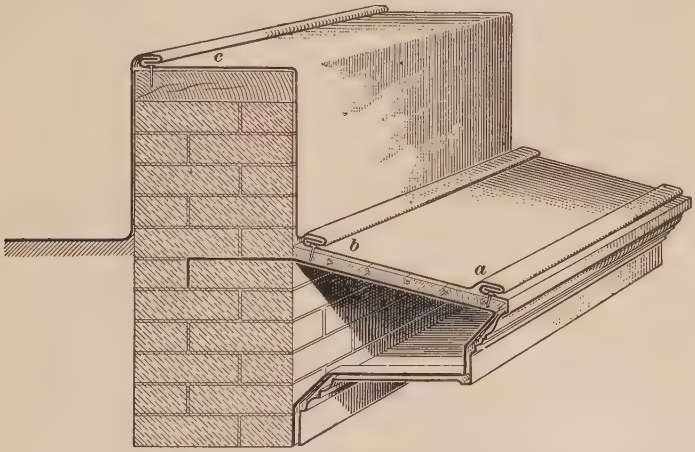


FIG. 23

36. Stone cornices may be flashed as shown in Fig. 24. The copper is bent over the face of the stone and doubled over with a beaded edge on the under side to form a drip.

This also prevents the flashing from rising in front. When the top surface is narrow—that is, less than 12 inches—it does not need to be fastened, but when it is wide, the copper should be held down with fastenings, as shown at *a* and *b*.

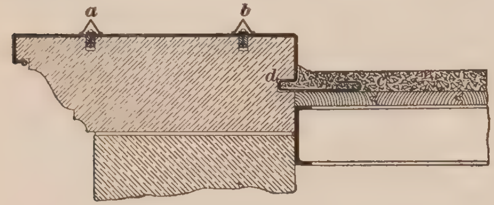


FIG. 24

The arrangement shown in Fig. 24 is used at the junction of a stone cornice and an asphalt roof laid on fireproof construction, the asphalt covering being shown at *c*. Sometimes the copper is bent down flat over the back of the stone, but the best method of attaching it is to groove the stone at the back and let the copper into it, as shown at *d*. This holds down the flashing at the back.

37. The common method of fastening the sheet to the stone is to drill ½- or ⅝-inch holes at intervals over the surface of the stone and fill these holes with lead. The holes should be cut wider at the bottom than at the top, so that the lead plugs cannot be pulled out. After the holes are drilled, an iron rod, whose diameter is less than that of the screws to be used, is greased and placed upright in each hole. Molten lead is then poured around the rod until the hole is full. The rod is then pulled out, and when the flashing is all laid and neatly set in place, it is screwed down to the lead plugs with brass screws.

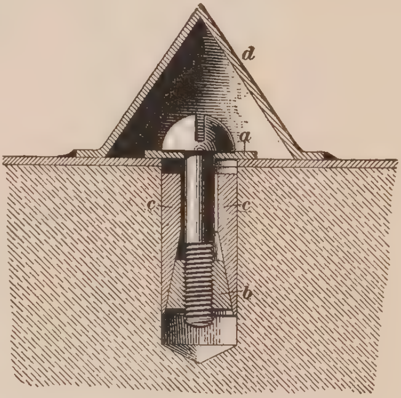


FIG. 25

Expansion bolts, shown in Fig. 25, are now generally used for fasteners. After the holes are drilled and the stone covered, the holes are "found" and the expansion bolts are inserted. A washer *a* is placed between the bolt head and the copper, and the bolt is screwed down tight. This draws up the tapered, or wedge-shaped, nut *b* and presses the sides *c*, *c* against the sides of the hole. A cone *d* is then soldered over the fastener, as shown, to make it water-tight. If the fasteners are not used, the copper is likely to rattle when the wind blows.

38. **Chimney caps** are made in different styles. The most simple, and perhaps most common, form is a plain sheet-metal cap that is slipped down over the brickwork about 6 inches, the sides of the cap being nailed into the joints of the brickwork. A superior chimney cap, however, is shown at *a*, Fig. 26. The brick chimney is built up to the course *b*, then the cap is bedded on, and finally the brickwork *c* is filled in from the top, so that its weight on the flange, which is turned over the course *b*, will prevent the cap from being blown off. The moldings of the cap, being of small projection, do not require any lookouts. The brickwork must, however, be built up tight to the top of the cap to prevent it from settling down and flattening the molding.

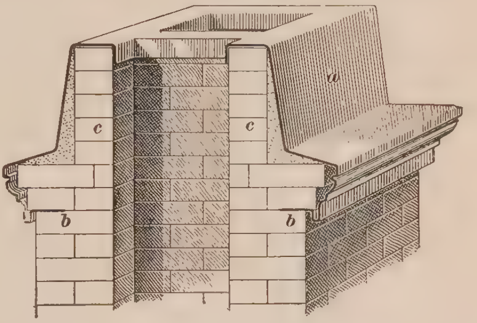


FIG. 26

BALUSTRADES

39. **Balustrades,** like cornices, etc., are constructed either with wooden or with fireproof supports, the kind to be employed depending on the construction of the building. Balustrades, pedestals, etc. on non-fireproof buildings are usually backed with, or secured to, woodwork, while those on fireproof buildings are nearly always supported by ironwork or brickwork.

Fig. 27 is a section through a balustrade that is commonly employed where the cornice deck pitches to the front and the roof pitches to the rear. The base rail *a* extends down to the deck, the metal being flanged over and soldered to the roofing.

When the deck over the cornice grades back toward the balustrade, and when the base rail extends down to the deck, it is necessary to solder in drain tubes to take away the water. This will prevent a pool of water from forming against the base of the balustrade. The trouble, however, with such tubes is that they are liable to become clogged with snow, etc. The best arrangement is to elevate the base rail 2 or 3 inches above the deck. Roof-cornice decks, in fact, should always pitch back to the roof to prevent rain from dripping over the cornice. When the base rail does not extend down to the deck, it is usually composed of solid timber and is entirely covered with sheet metal.

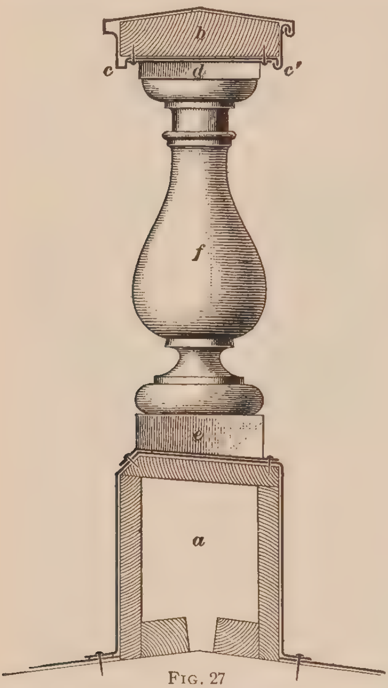


FIG. 27

To prevent the rail from sagging, wooden blocks covered with sheet metal are frequently inserted under the rail at distances varying from 6 to 8 feet apart. The coverings of these blocks are bent over at the top and nailed to the under side of the base rail, while at the bottom they are bent out and soldered as a flange to the deck.

The cap rail *b*, Fig. 27, is usually made of wood and is covered with two pieces of sheet metal with drips formed at *c*, *c′*, as shown. The seams are made at the rear.

40. The balusters *f*, Fig. 27, are spun, pressed, or cast. If they are spun or cast, there will be no vertical joints in their length. If they are pressed, they are put together in halves, which necessitates two vertical soldered seams. Pressed metal is generally used on ordinary work because it is much cheaper than spun or cast metal. The top member *d* and the bottom member *e* of the baluster are usually square. All the members are securely riveted and soldered together before the baluster is set in position. After the cap and base rails are in place and lined up properly, the balusters, which are hollow and flanged at top and bottom, are pushed into place. The flanges are securely nailed to the under side of *b* and to the top of *a*, as shown, the bottom flange of each baluster being soldered water-tight over the nail heads. The top flanges are not soldered, because the drips protect them.

It is generally understood that sheet-metal balusters are strong enough to support the top rail under ordinary conditions; but in cases where a load is likely to be placed on the cap rail, it is advisable to put a strut inside of each baluster, which will take the load off the metal and prevent the baluster from collapsing.

In fireproof construction, the general arrangement is the same, the principal difference being that iron backing is used instead of wood, and that the metal is bolted to the ironwork in a manner similar to that prescribed for cornices.

41. A **pedestal,** as ordinarily constructed, is composed of a framework made of 3″ × 4″ timber, which is spiked to the roof and sheathed, as shown in Fig. 28. The projections necessary for the moldings, etc. are blocked out. In the figure, the pedestal is provided with a panel face and a flat back. The sides may be paneled or plain. The dotted lines show the relative position of the balusters *a* and the cap and base rails with respect to the pedestals.

The sheet metal for the front and sides is made to fit the pedestal and is then put on in one piece. The back piece is then put in place and double-seamed to the sides, flanges *b*, *b′* being formed at the base and soldered to the deck. The top is then put on and double-seamed over a flange, as shown at *c*, *c*; the double seam is shown turned down and finished at *c*, while it is only half finished at *c*′. The molding, or projection at *d*, is returned on the pedestal and miters with the top rail. The base block, in a like manner, returns and miters with the base rail of the balustrade. If a finial or vase is to be set on the pedestal, the connection should be made with a flange at *e* and should be lock-seamed and soldered water-tight.

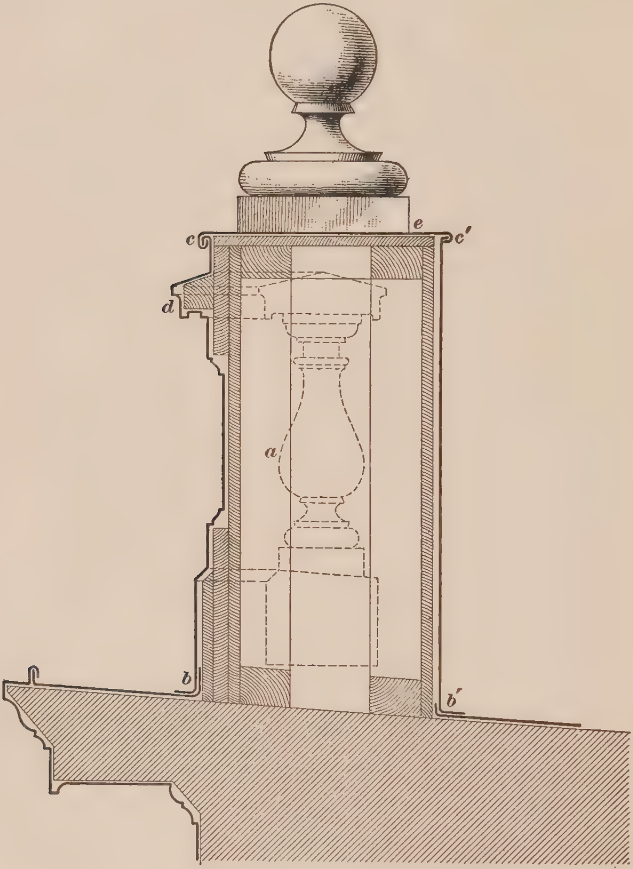


FIG. 28

Corner pedestals are paneled on two sides; this necessitates a vertical seam on the outside and inside corners of the pedestal.

In fireproof construction, the backing for the pedestals is usually composed of brickwork when they are located immediately over the wall head. The sheet-metal covering is then made up in one piece and is slipped down over the brickwork, being fastened to the deck with a flanged seam, as shown in Fig. 28. The top sheet, also, is fastened in a manner similar to that shown in Fig. 28.

When a tall finial that requires a support has to be set, it is advisable to run a rod or iron pipe up through the center of the pedestal and screw the top member of the finial to this support.

When a solid brick backing cannot be obtained, it is necessary to construct a framework of wrought iron, which is thoroughly braced diagonally and bolted to the roof. The metal covering is then placed around the frame, and bolted or riveted in position in the usual manner.

GUTTERS

42. The varieties of gutters that will be treated of in this Section are: *eaves gutters*, *roof gutters*, *parapet gutters*, and *belt-course gutters* of various materials and for various classes of buildings.

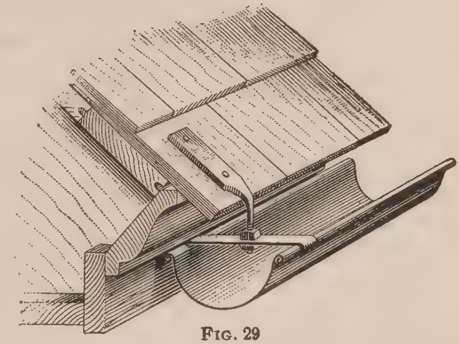


FIG. 29

An eaves gutter of the simplest kind is shown in Fig. 29; it is known as a **half-round hanging**, or **trough, gutter**, and is commonly used on ordinary frame buildings. The standard widths are 3, 4, and 5 inches measured across the top of the inside. The bead is about $\frac{1}{2}$ inch in diameter and is turned outwards. These gutters are suspended from the eaves with adjustable malleable-iron hangers set at about 3 feet centers. When they are attached to shingle roofs, the hangers may be simply nailed or screwed to the shingles as shown in Fig. 29. A neater method, however, is shown in Fig. 30, where the hangers are firmly nailed to the roof-boarding before the shingles or slates are laid. The pitch or grade of hanging gutters should not be less than 1 inch in 10 feet and the gutters should be hung low enough to allow the snow to slide over them.

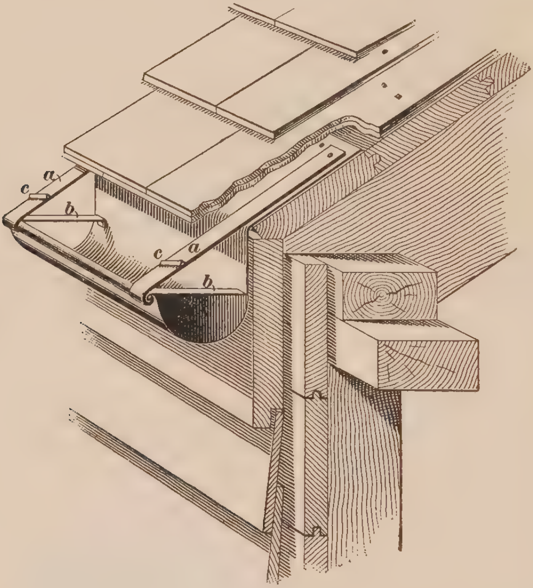


Fig. 30

Three-inch gutters are useful only for porches, bay windows, and other small roofs. The 4-inch size should be used on the main roof when the horizontal or projected area does not exceed 500 square feet. The 5-inch size is used chiefly on factories, warehouses, and at the rear of large city buildings, where the projected area does not exceed 1,500 square feet. Hanging gutters of this class should be used only when the eaves overhang the wall.

When a hanging gutter is attached close to the wall, the back of the gutter is extended up under the shingles or slates at least 6 inches, as shown in Fig. 30, the object being to prevent heavy winds from blowing rain drops against the siding. The gutter is held up in front by tension straps *a*, *a*. The lower ends of the straps are soldered to the bead, and the upper ends are nailed to the roof. Braces *b*, *b* are soldered inside, and above the water-line, to prevent the gutter from sagging or collapsing. Small clips *c*, *c* are soldered on the straps at an angle, to divert any current of water that may flow along the strap and thus escape over the edge of the gutter. This gutter should be graded about the same as that shown in Fig. 29.

43. Molded Eaves Gutters.—Molded, that is, ornamental, eaves gutters are often attached to buildings in a manner very similar to that shown in Fig. 30, but while the gutter in this figure is laid with a pitch, such molded gutters are laid perfectly horizontal. In this respect they are defective, because all gutters should pitch down to the outlet pipes. In good practice, it is advisable not to run a gutter with a horizontal bottom, not only because the gutter is liable to overflow during heavy rain storms, but because a pool of water will remain in the bed of the gutter after the rain has ceased. To prevent an overflow, it is necessary to make molded eaves gutters quite large; and to properly drain them, it is necessary in some cases to install a false bottom that will grade down to the point of outlet with a suitable pitch.

When the gutters are made of iron, they should always be graded in order to prevent deposits of mud, which hasten corrosion.

44. Fig. 31 shows a **copper molded eaves gutter** set on the top of a brick wall of a fireproof building, which is provided with a terra-cotta roof covered with slates. The bed of the gutter rests on a board *a*, which is inclined so as to give the proper pitch. The face of the gutter forms a continuous horizontal molding and is made from cold-rolled sheet copper. The front edge of the gutter lining is bent down over the face and is lock-seamed to the copper molding as shown.

The back of the gutter is extended up over the terra-cotta slabs *d* and under the slates *e*. A series of brass straps *c* are spaced off along the gutter and secured at distances of not more than 3 feet, being bolted to the plank *b* in front with brass lagscrews. The rear end of each strap is run up under the slates and bolted through the terra-cotta slabs with brass bolts of proper length, large brass washers or plates being used under the slabs to prevent the nuts from sinking into them. Each strap is twisted one-half of a turn, as shown, to prevent roof water from working over the face of the gutter. The sheet copper is doubled and pinched at *i* to form a drip. In cold climates, it is advisable to slope the back of the gutter, the space behind being thoroughly filled in solid. This will prevent the gutter from bursting with the formation of ice, if the conductor pipe should choke and the gutter fill with water.

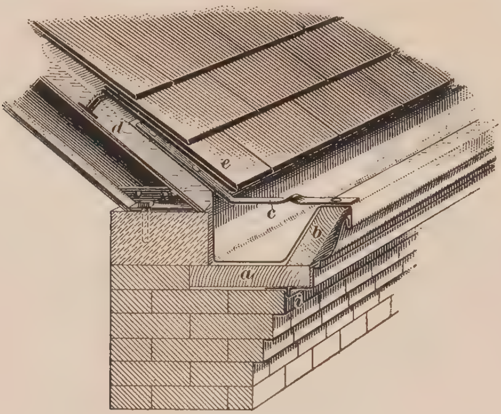


FIG. 31

45. Roof Gutters.—Fig. 32 shows a simple form of roof gutter. It consists of a board nailed to the roof and braced by brackets *a*, *a*. The board is laid on an incline to form the proper grade, and the lining, which is usually bright tin or terne plate, is continued up under the shingles, and nailed down. The front edge is doubled over a strip of metal that has previously been closely nailed to the woodwork. An edge fastened in this manner is called a *blind-nailed edge.*

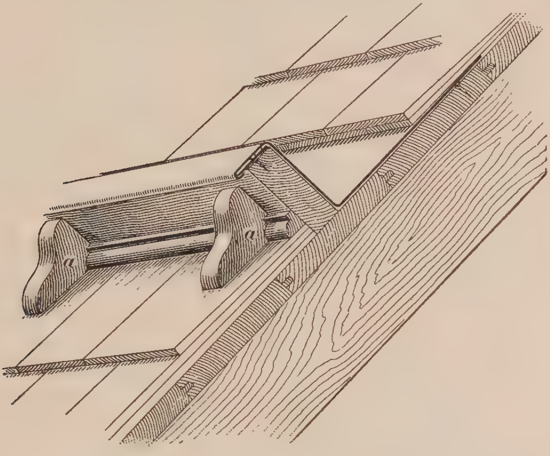


Fig. 32

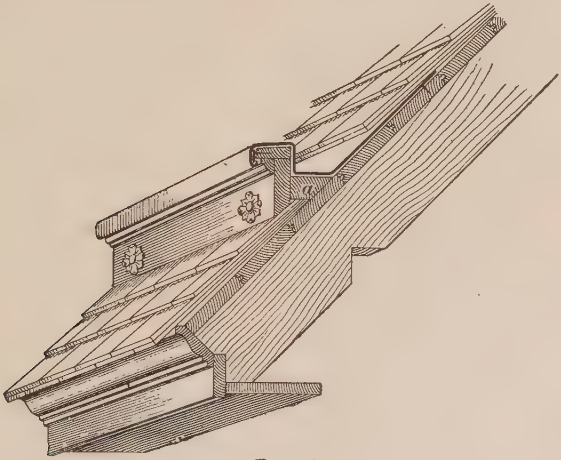


Fig. 33

The necessary incline of this gutter spoils its appearance; to form a roof gutter that will appear parallel with the roof, it is necessary to build it in a manner similar to that shown in Fig. 33. A tapering gutter strip *a*, usually 2 inches thick, is laid to run the whole length of the gutter, and grades the bottom in a proper manner. These gutters really form snow boards, and during winter often become so clogged with snow that the water from melting snow cannot run off the roof freely, but is forced to pass through between the shingles or slates and thus cause a temporary leakage. For this reason, roof gutters are not to be recommended for roofs with a low pitch.

46. Cornice Gutters.—The cornice of a building is very often constructed so it will serve as a gutter also. **A wooden cornice gutter,** sometimes called a *box gutter*, as shown in Fig. 34, is employed in the construction of the better class of framed buildings. The carpenter completes the cornice and forms the bottom of the gutter with the proper grade. The tinsmith then lines the gutter before the shingles or slates are laid. The lining, like those in Figs. 32 and 33, is nailed to the roof and over the front edge of the gutter with a blind edge, as shown.

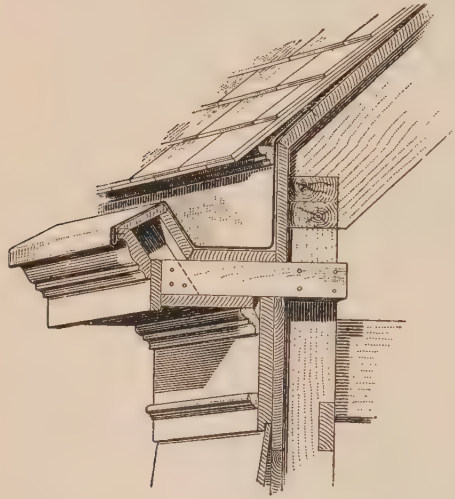


FIG. 34

Sheet-metal cornice gutters are constructed on the same general principle.

47. Terra-Cotta Cornice Gutters.—A terra-cotta cornice gutter for a fireproof building is shown in Fig. 35. The terra-cotta slab *a* of the cornice is backed by brickwork *b*, on which rest the **I** beams *c* of the roof trusses. The usual angle- or **T**-iron purlins support the porous terra-cotta slabs. The mason fills in the gutter bed *e* with cement concrete and grades it to the proper pitch. The sheet metal, which is generally 16- or 18-ounce soft- or hot-rolled copper,

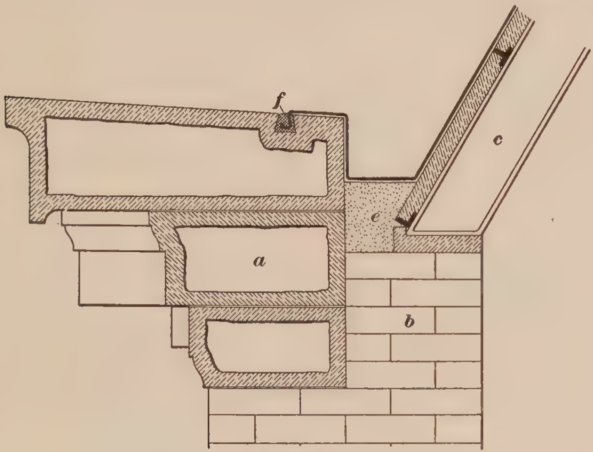


FIG. 35

is then bent up and laid into the gutter, the front edge being bent down into a groove *f*, which is molded in the terra cotta, and the back edge is run up the roof and is overlapped by the slates or tiles in the usual manner. The connection between the copper and the terra cotta is made water-tight by filling the groove full of molten lead, which, when cold, is solidly calked with a hammer and calking tool. If this method of attachment is not desired, the cornice may be molded with a dovetailed projection, so that the metal may be sprung over it as shown in Fig. 36. This will hold down the copper, but it is not so solid as the chalked joint shown in Fig. 35.

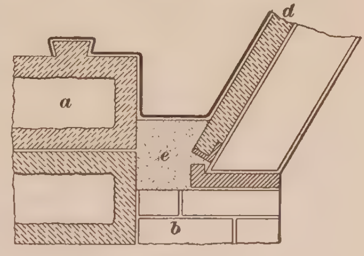


FIG. 36

48. Parapet Gutters.—A parapet gutter for a building of modern fireproof construction is shown in Fig. 37. The only notable difference between this and the box gutters already described is the fact that the gutter is located behind a wall that is higher than the point to which the gutter is extended under the slates. It will be readily seen that there is great danger of the building being flooded if the leader opening should become covered with leaves or dirt, so that rain water cannot escape down the conductor pipe *a* as fast as it flows into the gutter. To avoid this difficulty, an *overflow tube b*, having a sectional area at least equal to, but preferably greater than, that of the conductor pipe, should extend through the wall as shown.

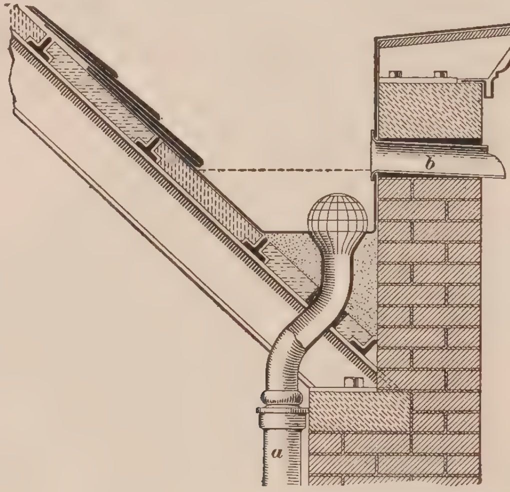


FIG. 37

The bottom of the overflow opening should not be less than 5 inches above the lowest point of the gutter bed, but not high enough to cause the water to overflow any upstands or flashings that the gutter may be provided with. In the figure, the sheet copper composing the gutter and the rear covering of the parapet wall is all in one piece; consequently, the main consideration in locating the overflow tube here is to prevent the water from backing up under the slates and leaking over the top edge of the flashing. The sill of this gutter, like that shown in Fig. 35, is filled in with cement and graded down to the conductor opening.

When the parapet wall is extended higher than about 18 inches or 2 feet above the gutter, it is customary to flash the back into the wall, as shown at *a*, Fig. 38. A joint in the brickwork is raked out to a distance of about 1½ inches, and the copper is bent over and let in as shown. Soft cast-lead bats *b*, *b* are then driven solidly into the reglet, about 6 or 8 inches apart, after which the reglet is filled with elastic cement. The objection to this arrangement, however, is that the expansion and contraction of the gutter is liable to loosen the bats, and the reglet joint may leak.

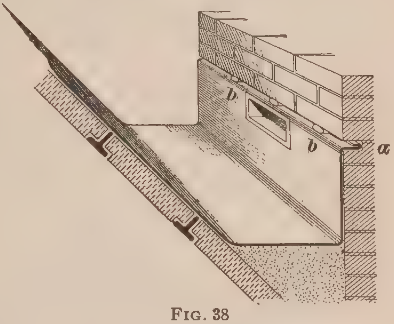


FIG. 38

49. A better arrangement is shown in Fig. 39, in which the gutter is not nailed down or secured at any point except at the conductor opening. The upstand *a* back of the parapet is held down by a number of *cleats b*, of which the tops are doubled over the top of the upstand and the lower ends are bedded in the cement sill. A counterflashing *c* of lead or copper is batted into the reglet and overlaps the upstand at least 3 inches. The top of the overflow tube *d* should be on a line with the top of the upstand or a little below it. To avoid nailing down the gutter at the back,

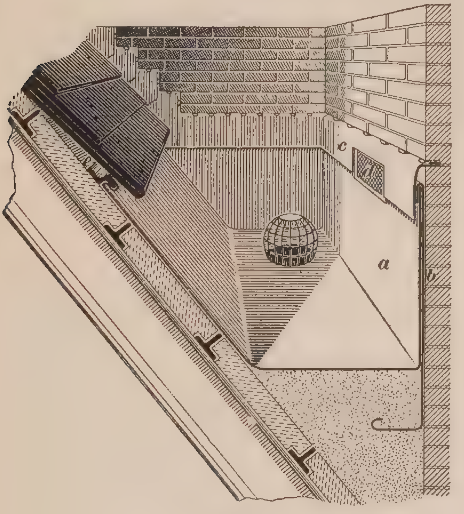


FIG. 39

also to prevent it from rising or shifting, an iron or brass *tilting fillet e* is bolted to the fireproof roofing. The sheet copper is bent under and doubled over this fillet, as shown. The tilting fillet is also advantageous to the slater, because it enables him to start the bottom course of slates with the proper cant.

50. Wooden Tilting Fillets.—Wooden tilting fillets are used when the roof is covered with boards. The fillet is shaped as shown at *a*, Fig. 40, and extends the full length of the gutter. A number of strong cleats *b* are nailed to the roof and bent over the fillet. The gutter is then laid and the cleats are doubled back over the edge, as shown. This is considered first-class practice. The method of laying slates or shingles flat on sheet-metal gutters, valleys, flanks, or other flashings should never be followed. Water will work up between them by capillary attraction.

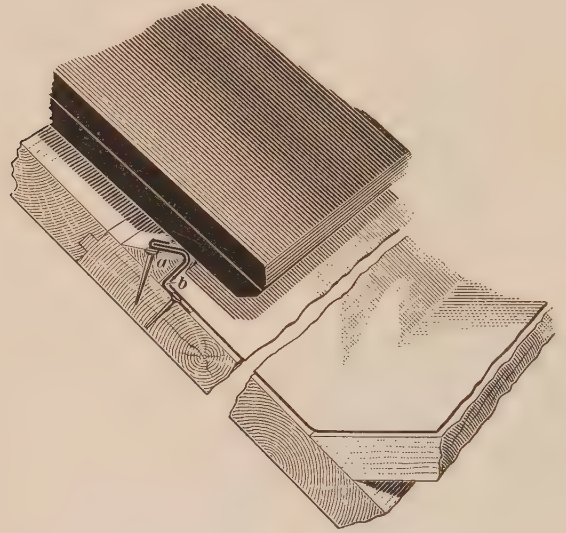


FIG. 40

51. Corbel-Table Gutter.—A corbel-table gutter is shown in Fig. 41. It is supposed to form a belt all around the building, being located about 4 or 5 feet below the eaves.

Such gutters, being so far below the eaves, do not carry much water at any time; they simply serve to carry off the drip. The greater part of the water shed by the roof during heavy showers, shoots over the gutter, this action being most pronounced when the roof covering is of a corrugated character.

A corbel table *a*, which rests on corbels *b*, *b*, forms a support for the gutter. The lookouts *c* are made of cast iron and are set at about 2 feet centers all along the table, their prongs being let into the mortar joint at the back about 2 inches. The crown molding and its wash are made of copper, the lower edge being lapped about 4 inches over the top of *a*. The top edge is fastened with cleats to an iron bar. Another iron strap, or bar, at *e* runs the full length of the gutter, and the copper is fastened to it with brass bolts. When the molding is in position and properly lined up, the mason fills in the gutter with cement to form a curved bottom with the proper grade. Strong cold-rolled copper cleats *f*

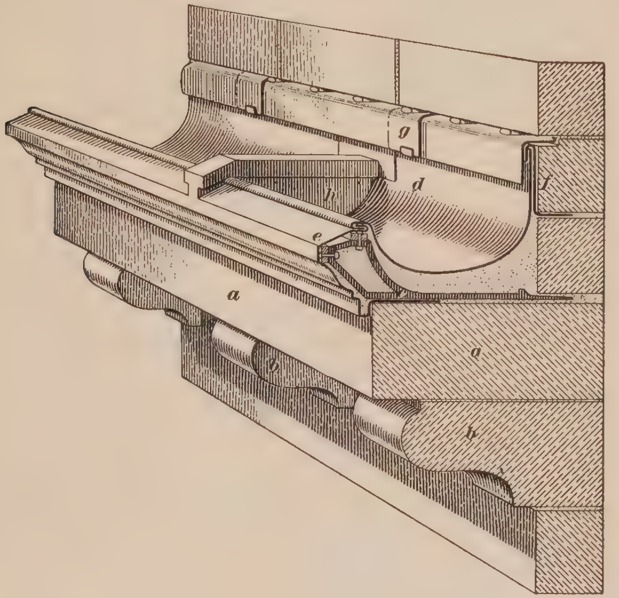


FIG. 41

are secured to the wall to hold down the back of the gutter *d*; the front edge is double-seamed and soldered as shown. The back is counterflashed in the ordinary manner. If the counterflashing is of lead, the top joints *g* should be locked into one another at the lower edge, as shown, to prevent the wind from raising the corners.

52. When such gutters are long, some provision should be made for expansion and contraction, otherwise they will soon tear apart and leak. In Fig. 41, this is accomplished by introducing a *saddleback joint* at *h*, a cross-section of which is shown in Fig. 42. A plank *i*, Fig. 42, 2 inches thick, that has been previously soaked in oil or asphalt, is set on edge and bedded in the concrete. If the gutters are laid during hot weather the upstands *j*, *j* should be fitted to almost touch the plank, so that during winter, when the gutter becomes intensely cold and contracts, the upstands will be drawn away from the board and take the position shown by the dotted lines. This forms an expansion joint of the best type. The cap, being short, is nailed to the wood and the nail heads are covered with a copper disk, which is soldered water-tight around the edge.

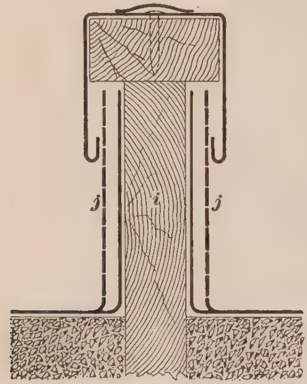


FIG. 42

CONDUCTORS

53. **Conductors,** or **leaders,** as they are often called, are the pipes that conduct or lead away water from the gutters. They may be classed as *inside* or *outside leaders*. Inside leaders are not treated in this Section.

54. **Outside Leaders.**—Outside leaders are fitted up against the outside of a building. They are made in many shapes and of different metals. Fig. 43 shows the **round-pipe leader** as usually erected. These leaders are most always made of tin by the tinsmith, who also makes the elbows *a*, *a*, *a*, which, usually, are altogether too sharp. Tin straps *b*, *b* are soldered to the leader at intervals of about 6 or 8 feet and are nailed to the walls, as shown. Round leaders are not suitable for outside service in cold climates because they persistently freeze and burst.

Fig. 43 illustrates an ever-recurring spectacle in cold weather, when snow lies on the roof and the temperature of the air is below the freezing point. The sun shines on the roof, but not on the leader; thus, the snow on the roof melts and the water trickles down the leader, and, by the time it nearly reaches the bottom it becomes frozen to the sides of the leader. This ice slowly thickens until the leader is entirely choked at that point which, in Fig. 43, is the lowest elbow.

The remainder of the melted snow then gathers in the leader and fills it. This water now solidifies and bursts the leader as shown. The pipe has burst because it could not stretch enough to accommodate the increase in volume of the water as it was changed into ice.

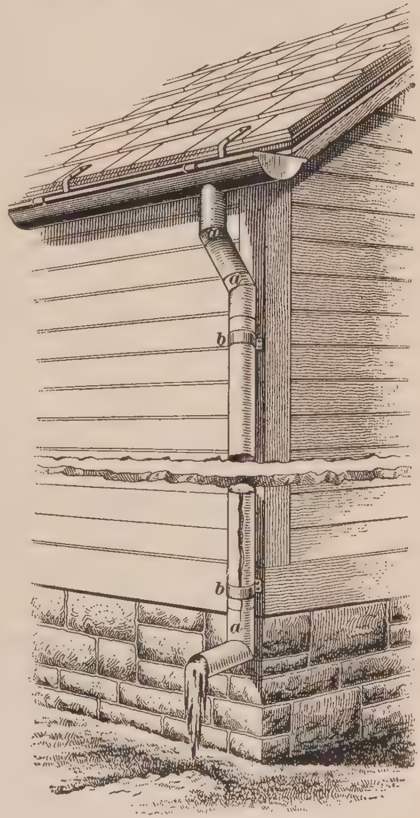


FIG. 43

55. Expanding Pipes.—Expanding pipes should be used to overcome the trouble from frost. A common form, shown in Fig. 44, is simply a corrugated round pipe. The corrugations allow the pipe to increase enough in diameter to compensate for the formation of ice inside, without bursting the pipe. If the pipe is frozen repeatedly, it will ultimately burst, because it takes a permanent set every time it is thus expanded. These pipes are usually made of galvanized iron or cold-rolled copper, in 8- or 10-foot lengths.

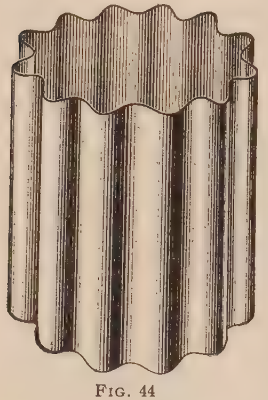


FIG. 44

56. Square or Rectangular Leaders.—These leaders are made of crimped or corrugated sheet metal, and are often used to obtain a more ornamental effect than is produced by round leaders. They should be supported by ornamental bands in a manner very similar to the plain straps shown in Fig. 43, the straps being made so that the leaders will hug the wall. If the walls are built of masonry or brickwork, it will be necessary to drill holes at the back of the bands, and then drive soft-pine plugs into these holes, cutting them flush with the face of the wall for the purpose of receiving the spikes; for good work, expansion bolts should be used.

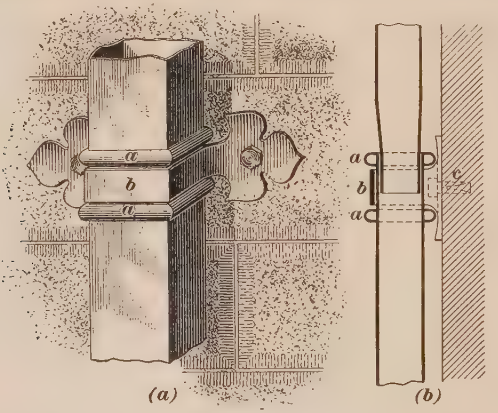


FIG. 45

In climates where there is no danger of outside leaders being frozen, the best method of attaching rectangular leaders in a neat and strong manner to brick, stone, or terra-cotta walls is shown in elevation in Fig. 45 (*a*) and in section in Fig. 45 (*b*). Two copper beads *a*, *a* are soldered around the top edge of each leader and a cast-copper band *b*, provided with ornamental lugs, clasps the top of the leader against the building. The lugs are fastened to the walls with expansion bolts, as shown by dotted lines at *c*. The leaders are connected together by slip joints, as shown in the section. Each band thus supports a section of the leader, which should not exceed 8 feet in length. This arrangement allows each section to expand and contract freely; if all the joints are soldered together, the leader forms into one long rigid line, which soon becomes loosened by expansion and contraction. These leaders should be made with the crimps running across them, not lengthwise, so as to secure a very neat, flat, and stiff surface.

Beaded tops and cast bands are not adapted for outside leaders in cold climates, because the beads and the bands are not pliable enough to resist the action of frost. The best attachment for such climates is composed of either a brass or a copper eye, which is riveted and soldered securely to the back of the top end of each section of the leader. These eyes are bolted to bronze hooks that are secured to the wall. An ornamental stamped sheet-copper band is then slipped on between the heads to conceal the real rigid attachment. The lugs of the band should be attached to the wall by expansion bolts. This arrangement gives a pliable joint. The corrugations in this leader, however, should run lengthwise, and all the joints should be slip joints. Iron supports should never be used in or against a stone wall, because they rust and stain the masonry.

57. Offsets in leaders should always be avoided. It is common practice to offset the leaders at stone, brick, and terra-cotta moldings, but in good practice they should be fitted up straight and plumb, the necessary holes being cut through special blocks formed in the molded courses for the passage of the leaders. It is customary to discharge sheet-metal leaders into a cast-iron pipe, which is continued up about 4 or 5 feet above the surface of the ground, the object being to prevent the leader from being flattened or otherwise injured. Rectangular leaders should, for the sake of appearance, connect at the bottom with a rectangular cast-iron pipe, and not with a round pipe.

58. **Size of Leaders.**—The proper size of leaders, of course, will vary with the climate, the amount of rainfall, and the manner in which the gutter catches the water; but a good safe rule for every-day practice is to allow 1 square inch of sectional area of conductor pipe for every 75 square feet of flat-roof area. No leaders, however, should be less than 2 inches in diameter, and even this size should be used only for small roofs, such as those over bay windows, small porches, etc.

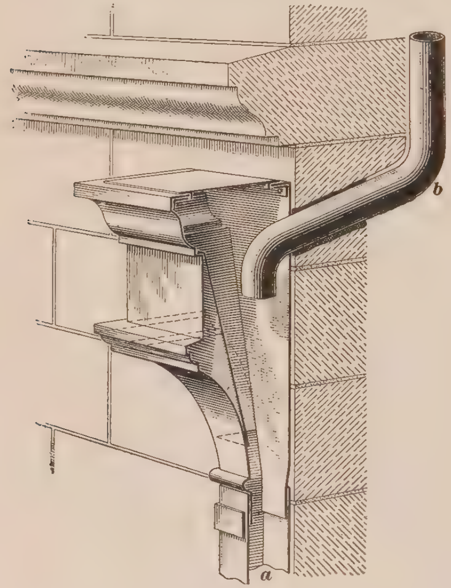


FIG. 46

The *underground pipe* (often drain tile), into which the leaders discharge, should not be less than 4 inches, inside diameter, and they need not be more than 8 inches in diameter for any work where the roof area is less than 1 acre. In measuring the watershed of pitched roofs, calculate the projected or horizontal area—that is, the area on the plan.

59. **Rain-water heads,** sometimes called *conductor heads,* are often employed on the top of a leader, and treated as an

architectural feature by forming a graceful outline to the receptacle for the gutter discharge. Two or more leaders may deliver into one head, as the conditions may require.

Fig. 46 shows a conductor head in section. It is set on top of a rectangular, corrugated, sheet-metal leader *a*, which should be securely fastened to the wall with a band on top. The lower end of the head slips into the conductor, and the top is fastened to the stone wall with expansion bolts or other fasteners. A brass angle should be fitted inside the rim. The roof gutter empties into the head through a large lead or copper pipe *b*, which runs up a chase in the back of the wall, thus concealing it from outward view. The top of the head should be covered to prevent birds from building their nests in it, or in the pipe *b*. The proper position for a rain-water head should be carefully shown on the elevation, as mechanics are prone to set them at the handiest place, without reference to the architectural treatment of the façade. All rain-water heads should be lined inside with a tapering box, to extend below all moldings and prevent possible leakage, and also to prevent noise during heavy rains.

60. Strainers.—Every leader opening in a gutter should be provided with a strainer to hold back leaves, twigs, etc., and to prevent birds from building nests in the leaders. The best strainers are those constructed of a ball or hemispherical form, like those shown in Figs. 37 and 39.

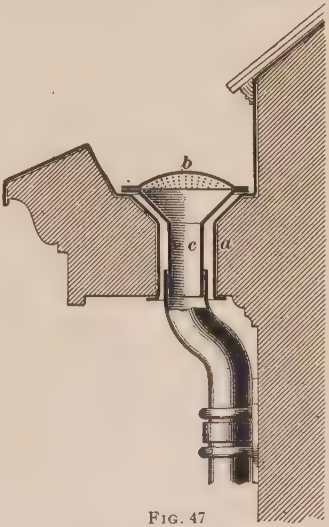


FIG. 47

For ordinary purposes, where the roof water flows to waste, wire ball strainers, put together something like bird cages, are generally used. But in cases where the roof water is gathered into cisterns or tanks and stored for domestic use, the strainers must be very close in order to prevent pieces of leaves, etc. from being washed down into the cisterns. Such vegetable matter soon decays and pollutes the water. The strainer *b*, Fig. 47, is specially made for this service. It has a very large straining area, which is closely perforated with holes not larger than $\frac{1}{8}$ inch.

61. Gutter connections to leader pipes are very important details and should be carefully considered. The offsets necessary for cornice and overhanging gutters should have a good grade from gutter to leader, and should be composed of easy bends—not sharp elbows. Owing to the fact that leaders are liable to freeze, it is advisable to provide outside gutter connections with a tube, as shown at *a*, Fig. 47. This tube is soldered to the gutter lining on top, and may be flanged over the face of the soffit of the cornice at the bottom, as shown, thus forming a water-tight channel through which the leader pipe *c* passes. If the leader should freeze and burst between the gutter and the soffit of the cornice, the tube *a* will prevent the water from leaking into the cornice, which, if made of wood, will soon cause the decay of the material.

When copper leaders connect with tin-lined gutters, or vice versa, it is advisable to make the gutter tube *c*, Fig. 47, of the same material as that used for the gutter lining. If different kinds of materials are employed for this purpose, a galvanic action may occur between the two metals, which will hasten corrosion. The connection of the gutter tube to the leader is made with a slip joint.

62. Leader Cut-Off.—When the leaders discharge into cisterns or tanks, it is advisable in all cases to provide them with cut-offs, so that the water may be discharged to waste or into the cisterns, as desired. Every roof is foul, to a certain extent, with decaying vegetation, bird lime, etc., and all this matter is washed off during the first few minutes of a rain storm. If a cut-off is not used, the dirt, of course, goes into the cistern. It is customary to leave the cut-off free from rain to flow to waste until the roof is supposed to be washed clean, then it is turned so that the remainder of the water will flow into the cistern.

There are many kinds of cut-offs on the market. Some are made to be operated by hand, while others are intended to operate automatically, when a certain volume of rain water has passed through to waste. The latter are preferable, if reliable, because the hand cut-off is likely to be neglected.

DOMES AND LANTERNS

63. In many parts of Europe, it is customary to cover domes, lanterns, cupolas, etc. with sheet lead; but, in the United States, owing to the great variations in temperature that are encountered, it is necessary to use a metal that is better adapted to withstand the unavoidable expansion and contraction.

Sheet copper or galvanized iron are the best metals for use in countries where excessive changes in temperature occur. The latter, however, is not durable enough for covering domes, lanterns, or cupolas, and, consequently, sheet copper is generally employed.

There are different methods of covering domes, but the following four may be considered preferable: namely, *plain* or *smooth*, *ribbed*, *paneled*, and *metallic shingle* or *slate coverings*.

64. **Smooth covering** is usually put on domes in a manner similar to that employed in flat-roof covering, with flat locked seams, each sheet being well tied down with strong cold-rolled copper cleats. If the dome is large, the ordinary flat sheets about 20 in. × 28 in. are generally used, the curvature of the dome being so slight that the soft copper will easily adapt itself to the shape. When the dome is small, however, each sheet must be blocked out to the proper curve, so that the covering, when finished, will have a neat smooth appearance and be free from buckles. The greatest objection to locked-seam covering is the liability to leakage, chiefly through the seams, on the nearly horizontal parts of the dome. The solder will spoil the appearance of the dome if the copper work is allowed to retain its natural color.

65. Ribbed Surface Covering.—To avoid leakage on domes by the effects of expansion and contraction, and to prevent any solder from discoloring the copper work, some form of ribbed covering is employed. This requires the use of a standing or a roll seam, as the character of the building may demand.

The space between the standing seams or rolls should not be more than 2 feet wide, and the sheets should not be more than 4 feet long. They must be securely supported from the top edge, preferably with heavy cold-rolled copper cleats.

It is advisable in all first-class sheet-metal roofing to avoid driving nails through the sheets at any point. The sheets are thus permitted to freely expand and contract without tearing the metal.

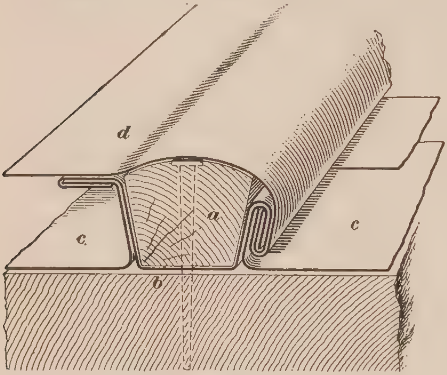


FIG. 48

An excellent roll seam is shown in Fig. 48. The batten, or roll strip, *a* is nailed down over a long cleat strip *b*. The sheets *c*, *c* are then sprung in between the rolls and the cleat strip is doubled over the upstand. The roll cap *d* is then put on over the roll, and locked into the cleated upstand as shown. The roofing sheets, cleat strips, and roll caps are thus all locked together and made water-tight, and yet are free to expand and contract individually. The batten nails combined with the outward curvature, which the sheets *c* must necessarily have, will prevent a gale from rattling or loosening the sheets.

66. Horizontal Seams.—The best form of horizontal seam that can be made on domes is shown in Fig. 49. A strong cold-rolled copper cleat strip *a* is nailed to the roof with flathead brass or copper nails; and the top edge of the under sheet, the bottom edge of the upper sheet, and the cleat strip are all locked together as shown. With this arrangement, each sheet can expand and contract lengthwise without affecting the stability of the support. If the sheets are simply lapped at this seam, the wind will get underneath and raise them in the middle, thus opening the seams and making them visible from the street.

When it is required to set the rolls more than 2 feet apart, it becomes necessary to support the sheets between the rolls. This is accomplished in different ways. The sheets may be laid so that the horizontal locked seams will be about 18 or 20 inches apart, the rolls being perhaps 4 or 5 feet apart. When very large sheets must be used, however, *secret tacks a*, Fig. 50, are riveted and soldered to the back of the sheet *b* at intervals, which will allow about 2 or 3 square feet to be supported by each tack. As the sheets are being put on, the tacks are pushed into long, narrow holes in the woodwork, and then pulled through and nailed to the inside of the dome as shown.

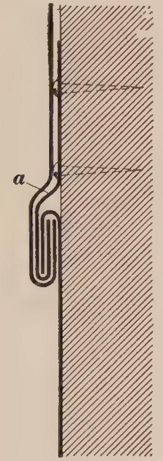


FIG. 49

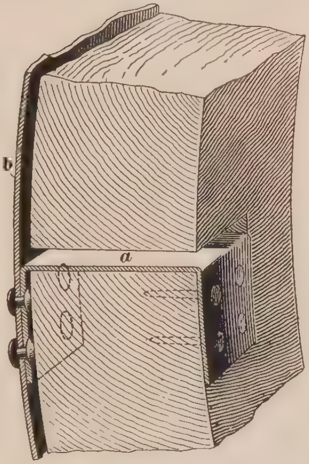


FIG. 50

67. Location of Rolls.—In locating the position of the rolls, it is necessary to consider the general construction of the edifice, both above and below the dome. The ribs or rolls should not be put up to suit the standard stock sizes of copper sheets, but they should be located to harmonize with the leading architectural features of the composition.

For example, consider the dome of the cupola, or lantern, shown in Fig. 51. The ribs here divide the dome surface into equal sections, two sections being immediately over each window opening. Every second rib is directly in line with the center line of a column. When the sheets are drawn closely together at the top, as shown, the ribs are usually tapered, being wider at the bottom than at the top; but when there is considerable space between the top ends of the ribs, they are usually made the same width throughout their length.

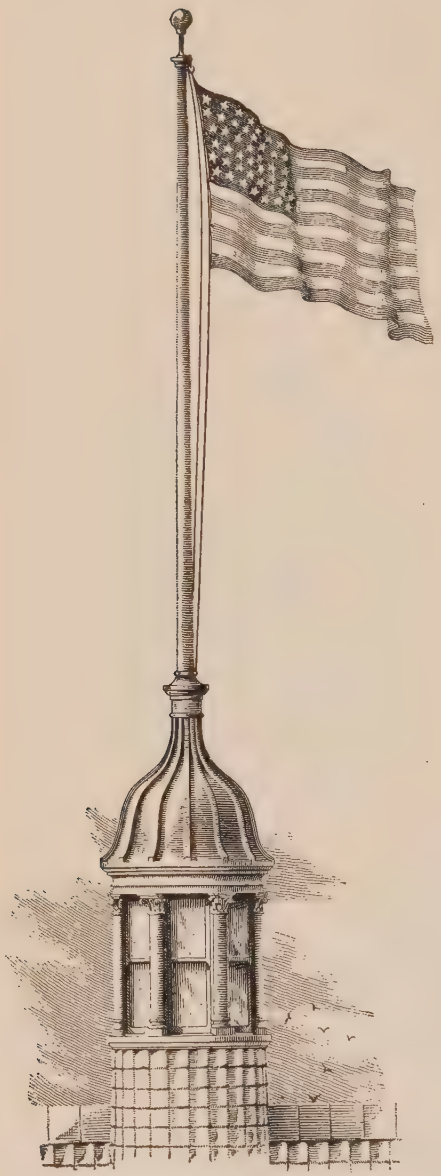


Fig. 51

68. The Paneled Dome.—A paneled dome is shown in elevation in Fig. 52. The lantern under the dome is octagonal in form, with a window *a* in each side. The dome, however, is round in plan with a panel *b* located directly over each window. The top of the dome is surmounted by a statue, the base of which is shown at *c*. A vertical section through the dome and a few details are shown in Fig. 53. The elevation, Fig. 52, shows ribs *d*, *d* running from the cornice of the lantern up to the base of the statue, but these may be omitted.

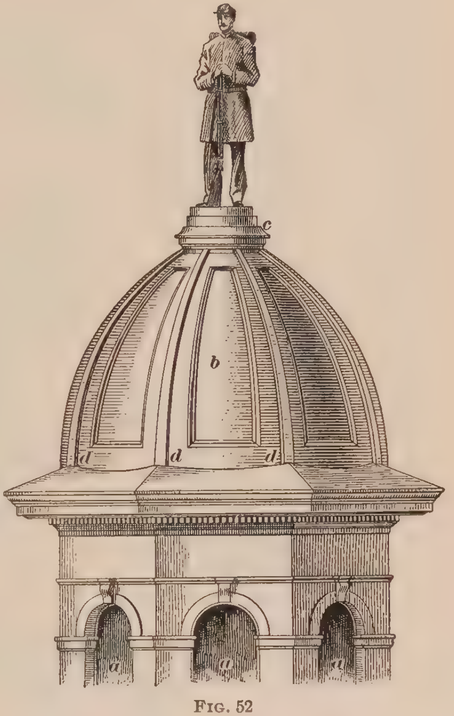


FIG. 52

At *e* in the detail, Fig. 53 (*a*), is shown a method of securing the panels in place without ribs, when there is no panel molding. The panels are simply double-seamed with cleat strips to the stile strip *e*, as shown. But where ribs are desired on the stiles, or when moldings must be run around the panels, the connections may be made as shown at *f* in the same detail. If the panels have a larger surface than 3 or 4 square feet, secret tacks may be employed to advantage, as shown by dotted lines. A detail of the top molding of each panel is shown in view (*b*), and a detail of the bottom and the wash over the corona of the lantern is shown in (*c*). These seams are all made in the shop, being locked and thoroughly soldered at the back, with the exception of *i*, which is made in place and is thoroughly cleated and soldered. The statue base *c*, Fig. 52, is slipped down over a sheet-copper collar, and is fastened to the top of the dome with four bronze bolts, which are threaded close under their heads to make a permanent water-tight connection. Fish-plates and nuts are employed underneath in the ordinary manner.

69. Flagpole Flashings.—Flagpole flashings, and those around all other forms of movable finials, require much attention to detail, as they must be made water-tight, and remain water-tight under peculiar conditions. Every flagpole sways more or less, according to its strength, the pressure of the wind, etc., and, therefore, a rigid flashing at its base cannot be durable. The liability of the pole to "settle down" is another matter to be considered. On this account, it is advisable to use *slip joints*, or telescope flashings, which

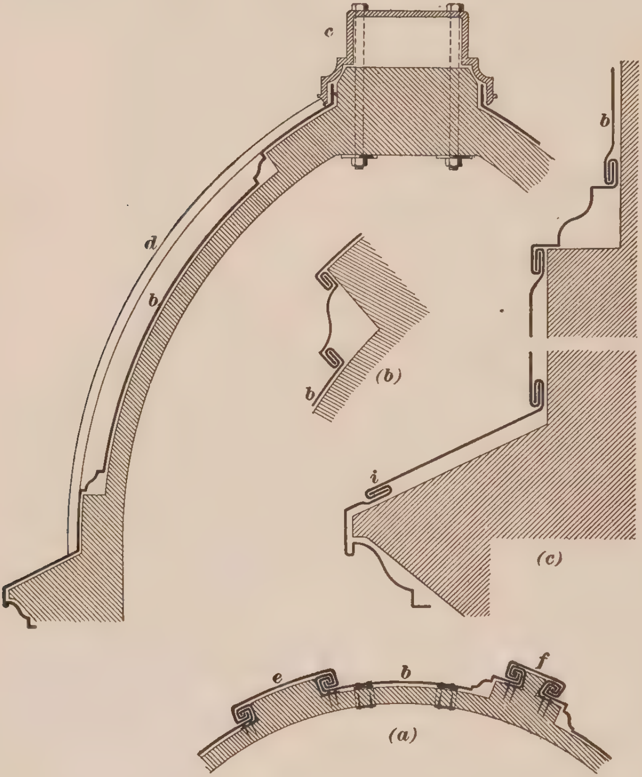


FIG. 53

are provided with enough clear space, or "play," to allow the pole to move or sway in any direction without touching or affecting the sheet-metal covering of the dome. A good arrangement is shown in Fig. 54, which is, in fact, a detail of the intersection between the flagpole and the cupola shown in Fig. 51. The rolls of the dome finish inside of the bead *a*. The copper work finishes around the top member *b*. A bonnet *c*, made of sheet lead weighing 8 pounds per square foot, encircles the pole and covers the member *b*. The top of the bonnet is "dressed" close into a small groove in the pole, which is cut just deep enough to allow the lead to finish flush, a bed of red and white lead being used to make the connection water-tight. The bonnet is nailed to the pole with a ring of 1-inch, pointed, flathead copper nails, which may be concealed with a bead *d* if desired. The lower edge of the bonnet overhangs the block *b* and forms an open lap joint around the top of the copper. The top of the block *b* is well greased, and the bonnet is free to slide as the pole sways.

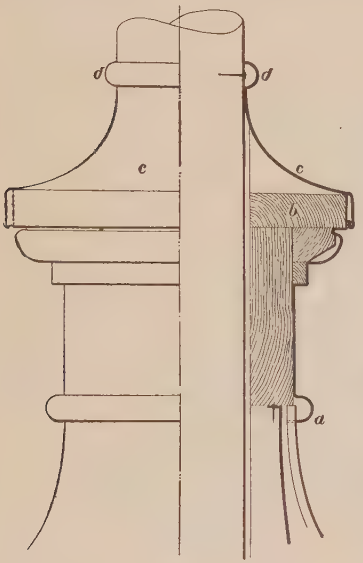


FIG. 54

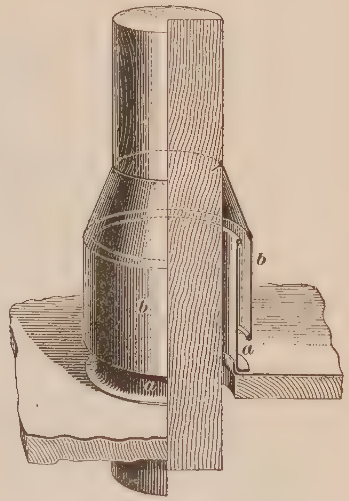


FIG. 55

When the pole intersects a flat roof, a plain slip-joint connection, like that shown in Fig. 55, may be used. A cylinder, or upstand, *a* is soldered to the roof. A sleeve *b* overhangs the upstand and is nailed to the pole as shown, a space being provided on each side of the upstand to allow the pole and its flashings to move in any direction.

70. Flagpole Cap.—The top of a pole should always be protected either by a sheet-metal flashing or by a cap. A flagpole cap, with regulation ball, is shown in Fig. 56, which is a detail of the cap shown in Fig. 51. A brass casting *a* fits snugly over the top of the pole and is fastened to it with brass screws. An eyebolt at the left holds the flag pulley. A piece of brass tube *b* joins the cap to a brass spud *c*, which is soldered to a seamless copper ball.

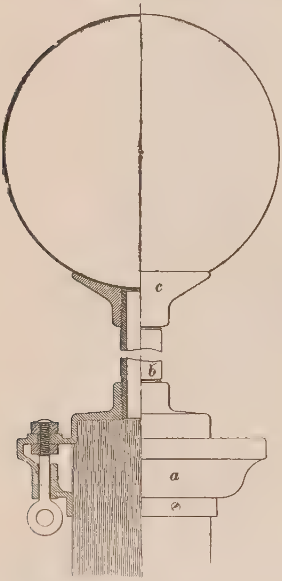


Fig. 56

This style of cap not only protects the pole from the weather, but provides a suitable pulley connection, and gives an artistic finish to the apex of the flagpole.

CRESTINGS

71. Sheet-metal crestings are of varied design and construction; they can, in fact, be made in any design that is adapted to stone or terra cotta. The most important features to consider in crestings are the method of support and the connection to slate or shingle roofs. Ordinary crestings are so constructed that the nail heads in the top course of slates are left exposed to the weather. This is a mistake, as rain will certainly follow the nails and cause slight leakage, which may not be visible, but which nevertheless, hastens the decay of the timber and rusts the nails.

72. Attachment.—Fig. 57 shows a method of attaching sheet-metal cresting on ridges and hips in such a manner that all nail heads are concealed. Channel strips *a*, *a* of strong sheet metal are bent to the shape shown and nailed on the roof close to the ridge pole. The top course of slates is then pushed in the channel and fastened with the nails *b*, *b*, as shown. The cresting *c* is then sprung over the channel strips and the lower edges are closed into them, thus locking the cresting and the channel strips together. The edges at *d* are locked together to prevent wind from lifting or rattling the cresting. When the ornamentation projects more than 9 inches, it is advisable to nail suitable lookouts on the top of the ridge pole.

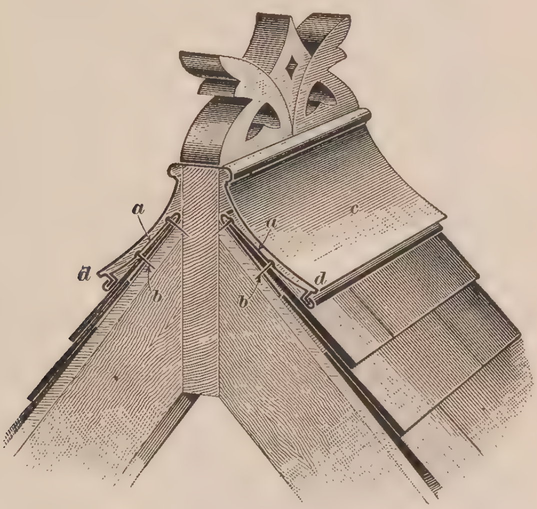


FIG. 57

The joints in crestings should be made in a manner similar to that already prescribed for cornices.

FINIALS

73. Finials less than about 7 feet in height are usually built in the shop to conform with the drawings of the architect, and are taken to the building and erected in one piece. Larger finials, however, are usually set up in two or more pieces, according to their height, weight, and form. All the joints should be double-seamed and soldered inside, in the same manner as cornice joints.

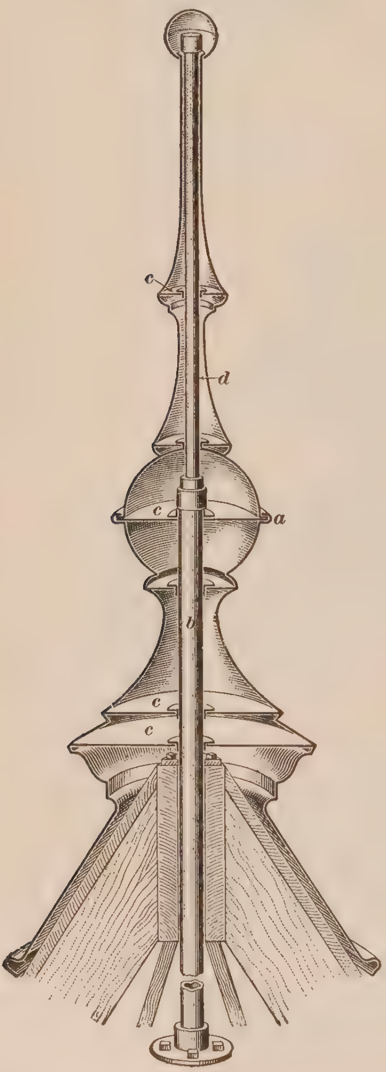


Fig. 58

Finials having round members are built up from either *spun* or *pressed metal.* Spun metal is preferable. Other forms are built together in different ways, according to the shape of the members.

All finials should be securely supported to prevent them from sagging, and braced to prevent them from leaning out of plumb. The system of supporting and bracing required will depend on the shape and the size of the finial. In some finials, a straight iron pipe alone will form a satisfactory support, while others must be provided with lookouts, like cornices, and often with braced framework. Fig. 58 shows a simple and efficient method of supporting a long narrow finial on the peak of a conical roof. This finial is taken to the building in two pieces, and is joined together in position, with a lock seam *a* around the ball. A 2- or 3-inch galvanized-iron pipe *b* is securely supported and braced to the framework of the roof. Horizontal partitions *c*, *c* are soldered to the inner surface of the finial and snugly fit the

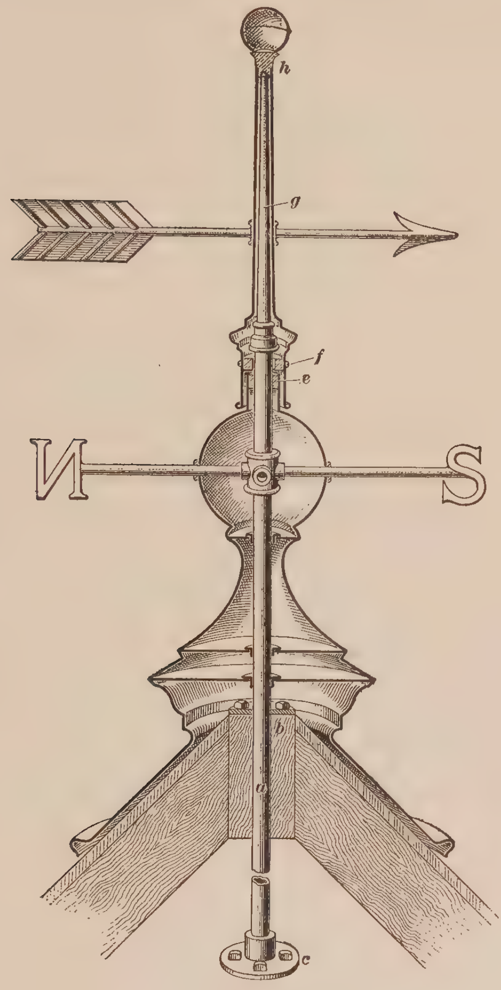


FIG. 59

iron pipe; these form braces and keep the finial straight. A few vertical gussets are soldered inside the ball to strengthen it vertically. A threaded pipe coupling is soldered inside the top ball so that this ball may be securely attached to the top of the pipe *d*.

74. Weather vanes are a class of finials provided with a movable part that rotates on a vertical axis by the force of the wind. They are employed to show the direction in which the wind blows and consequently are provided with the letters N, S, E, W, located respectively north, south, east, and west of the axis of the finial. These letters are secured to the stationary part of the finial. An arrow, or some other form of indicator or pointer, is also employed in the construction; this is attached to the movable part of the finial. Fig. 59 is a vertical section through a simple weather vane. It is similar to the finial shown in Fig. 58, except that the top part is made to rotate. An iron pipe *a*, which rests on a solid footing, passes vertically through the apex of the roof. A collar at *b* and a cross-beam at *c* rigidly secure the pipe and keep it plumb. A special fitting, called a *double-cross*, receives the arms that support the four letters already mentioned. These arms also reinforce the ball. The top of the stationary sheet-metal work is riveted to a brass ring *e*. The bottom of the movable part of the vane is bolted to a brass ring *f*. These rings keep the copper in proper shape at the slip joint. The lower end of a tapered steel bar *g* is screwed into the reducing socket on top of the pipe. The top end of the rod is tapered off to a sharp pivot point, and works in a brass socket *h*. This rod must be free and clear from the copper shell around it, so that the arrow may swing around to face the wind with the least possible resistance. The movable section must be carefully balanced; it should be so sensitive that a man can move it with his breath. The ring *f* is located under the reducing socket, and prevents the movable section from being thrown off in a storm.

75. Interior Sheet-Metal Work.—Sheet metal is seldom used in the interior of buildings except for covering walls, ceilings, etc., and even then it is only used for a cheap grade of work, so as to obtain the most elaborate effects at a very low cost. The principal items for consideration are the methods of fastening the sheets to the building and the selection of a design from manufacturers' stock.

It is customary for the sheet-metal worker to nail furring strips on the ceiling and walls at such distances apart as will conform with the design stamped on the sheets, but in no case should they be more than 1 foot apart. In selecting the furring strips for ceilings, particular care should be taken to allow for sufficient depth for any electric-wire conduits or gas pipes. The sheets are laid on the walls to overlap one another, and the nails are driven through the ornamentation in such a manner as to apparently form a part of the decoration. The lap seams should all be laid so that the light from the windows will shine against the edges of the sheets and thus avoid shadows, which would indicate the location of the seams.

All sheet-metal wainscoting, baseboards, dados, and chair rails, and, in fact, all ornamental sheet-metal work that is likely to be damaged by rough treatment, should be "pugged" behind with Portland cement.

All heavy moldings and cornices should be backed by lookout brackets cut to the proper profile. All wood backing should be covered with asbestos sheets when it is desired to form a fireproof enclosure. Plain black-steel sheets should be dipped in iron oxide and linseed oil before they are put up. In all damp places, it is advisable to use bright tin or zinc; the latter is preferable.

MATERIALS USED IN SHEET-METAL WORK

76. **Black iron** or **steel** is used only for the very cheapest roofing and siding, also for interior decoration or fireproofing. No. 26 gauge is generally used. In all cases, the sheets must be protected against corrosion by metallic paint or other suitable coatings.

77. **Galvanized iron** is used for sheet-metal siding, cornices, plain brackets, plain trusses, plain modillions, corrugated roofing, etc. No. 26 gauge metal is generally used throughout. No. 24 metal, however, is preferable for all large moldings.

78. **Zinc** is seldom used for covering buildings in the United States. But owing to the fact that it can be pressed into ornaments better than iron, it is employed for ornamental trusses, brackets, modillions, rosettes, festoons, etc., in galvanized sheet-metal fronts, and for balusters in balustrades. All zinc and galvanized sheet-metal work may be soldered on the face. All galvanized ironwork should be painted with a zinc body paint.

79. **Cold-rolled copper** is always used for copper cornices, moldings, columns, and all plain surface work that is to be formed in copper. The weight of the copper should not be less than 14 ounces, and it need not be more than 20 ounces on the very best class of buildings; 16-ounce copper is commonly used on good work, while 18-ounce is reserved for heavy moldings. All cold-rolled copper work should be fastened in place with brass or copper nails, screws, or bolts, as the conditions may require. All soldering should be concealed. When it is desired to paint copper work, the metal should be tinned all over the face to prevent the copper from coming in contact with the paint.

80. Soft-rolled copper is often called *hot-rolled copper* and is used for lining gutters, valleys, etc., and for pressed or hammered ornaments. The weight generally specified is 16 ounces, and 18 or 20 ounces on such work as may be subject to much wear and tear, either by expansion and contraction or by rough usage.

Soft copper, tinned on both sides, is best adapted for gutters and all other work that depends on solder for tightness and strength. Copper cleats should always be cold-rolled.

81. Soldering.--Sheet-metal seams should be soldered very slowly, because it takes time to properly sweat a seam, and very hot, well-tinned, soldering irons should be used. Any mechanic discovered "rushing" a seam or hastily skinning it over with solder should be immediately discharged and all his work should be resweated by a careful man, as the durability of sheet-metal work depends chiefly on the soldered seams.

Resin should be used as a flux for all tinned copper, and chloride of zinc for all plain copper, galvanized iron, and zinc. Raw muriatic acid or sal ammoniac should not be used as a flux.

82. Tarred roofing felt should be laid under all sheet-metal roof work and gutters, to protect the under side of the metal from moisture and deleterious vapors, also to form a soft protecting cushion for the metal.

83. Woodwork.—All woodwork under sheet-metal roofing should be smooth and evenly laid and properly graded by the carpenter. Nail heads, knot holes, and sharp corners are detrimental to sheet-metal work.

ORNAMENTAL METAL WORK

(PART 1)

CAST-IRON WORK

INTRODUCTION

1. Iron is used in building construction to serve two purposes, one structural and the other ornamental; but becomes an element of architectural consideration only when both purposes are combined. Unfortunately, the facility with which iron may be cast or wrought into any desired form renders the execution of the whole façade of a building as simple as though it were constructed of wood, and imbues the ironwork designer with a tendency to ignore the characteristics of the material with which he is working, and to execute columns, capitals, and friezes in cast iron with fidelity to original examples that were carved in stone and whose designs are ill suited to iron.

However, the incombustible character of this material, and the fact that its use materially shortens the time and decreases the expense of erecting a building, render it certain that iron as a building material is as important in the 20th century as was stone before the Christian era; and instead of condemning it as an "unarchitectural material," as some are inclined to do, it is our duty to study its character and possibilities in design and to develop a system or scheme of design that will be consistent with the conditions imposed by the material and its structural use.

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To do this, it will be necessary to understand the method of manufacture and difficulties attendant on the execution of any design in ironwork, so that in preparing a design it can be kept free from impossible demands. For instance, if the design is for a piece of cast-iron work, the designer must provide a means of molding the form properly and of getting the fluid metal into the mold without injuring any of the finer details. If the design is for a piece of wrought-iron work, such as a grille or a railing, provision must be made for enough space to permit riveting, hand welding, etc.

Thus, it will be seen that a careful consideration of the methods used in general shop practice will be the best way for the ironwork designer to advance in the comprehension of his work. This Section will therefore treat of the details of shop and field work in connection with the manufacture of iron for architectural purposes; and, therefore, the illustrations of working drawings used herein to elucidate the text are reproductions of drawings that have actually been used in the preparation of ironwork for some of the most important buildings in the United States.

Within certain limits, all that is necessary to know in regard to patternmaking and molding will be indicated in a general way; but, as in all other industries, new methods are constantly being adopted in working out the details of the various problems as they arise, although the basis of the operations remains the same.

METHOD OF MANUFACTURE

DEFINITIONS OF TERMS

2. Cast Iron.—The material obtained by melting iron ore with coke in a furnace is called *pig iron*. When the latter material is remelted and poured into a suitable receptacle, or *mold*, and allowed to cool and solidify, it constitutes **cast iron.** Cast iron is hard, brittle, and somewhat crystalline in its composition—that is, it shows on its fractured surfaces an appearance resembling an aggregation of small crystals, instead of a fibrous fracture like wrought iron. It is used, architecturally, for columns and newel posts, and, under certain conditions, for lintels or beams; but, owing to its lack of tensile strength, it is not well adapted to conditions of transverse strain. Cast iron is also formed into slabs for the purpose of stair treads, pavements, etc., and some forms of ornament are cast and attached to structural details.

3. **Molds** are the receptacles into which the molten metal is poured to give it some definite form consistent with the purpose that cast iron is to serve in the building. The molds are made by impressing in sand a cavity or a number of cavities that correspond in shape and relation of parts with the contour of the object to be cast. The process of so impressing the sand is called *molding*, and is effected by means of a wooden, plaster, or metal model of the object, called a *pattern*, which is so embedded in the sand that it will leave its impress when withdrawn.

4. **Cores,** as the word implies, are those parts of the mold that form the inside of hollow castings, and also means any parts of the sand mold that are made separately and placed within the principal mold. They are made of a mixture of sand and flour, or oil, and with the exception of very small cores, they are usually stiffened by running an iron bar lengthwise through their middle.

5. **Casting** is the operation of pouring the molten iron through the inlets—or *gates*, as they are called—into the sand mold from which the pattern has been withdrawn. All of the details just described culminate in the casting. The making of the pattern, with its allowances for shrinkage and draft, the preparation of the mold with its gates, and all the details attendant thereon, are for the sole purpose of securing a perfect casting, and all conditions and contingencies must be considered before the metal is poured.

6. **Patterns** are generally made of wood or of plaster, and occasionally partly of each. Where there are to be a

great many castings of one kind, the pattern is sometimes made of bronze or iron, in order to withstand the wear, but even in such cases the bronze or iron pattern would be cast in a mold originally impressed with a wooden or plaster model. Whether a pattern shall be of wood or plaster depends entirely on the character of the work. Patterns for plain straight work, such as molded panels, stair strings, columns, etc., are generally made of wood; but ornamented moldings, decorated panels, complicated capitals, etc. are first modeled in clay or wax, from which a cast is taken in plaster.

All patterns must have an allowance made for *shrinkage;* that is, the contraction and consequent decrease in size that every casting undergoes in the process of cooling. In ordinary work, this amounts to about $\frac{1}{8}$ inch per foot in every direction; so that the patternmaker should use a *shrinkage rule* to lay out his work. The shrinkage rule is usually a little over 2 feet in length and the divisions on it corresponding to 1 foot are in reality 1 foot and $\frac{1}{8}$ inch, and the subdivisions are proportionately excessive. Consequently, the pattern for a cast-iron bar 1 foot long, 3 inches wide, and $1\frac{1}{2}$ inches thick, would measure 1 foot $\frac{1}{8}$ inch long, $3\frac{1}{32}$ inches wide, and $1\frac{33}{64}$ inches thick.

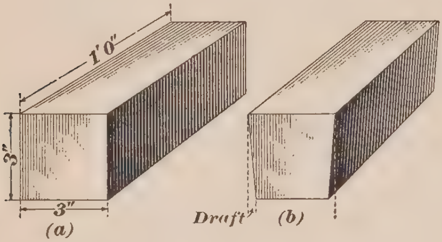
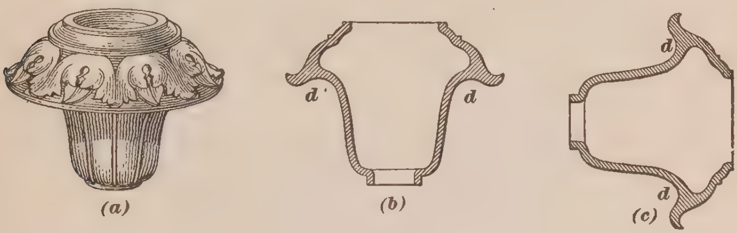


FIG. 1

In order that they may be freely withdrawn from the mold, patterns are worked with a *draft*, or taper. For example, if the object to be cast is a solid bar 1 foot long and 3 inches square in section, as in Fig. 1 (*a*), it will be found, in lifting the pattern from the mold, that the sand has a tendency to cling to the sides and thus destroy the mold; but if the sides of the pattern are slightly beveled, as in (*b*), this tendency will be overcome, and the sides of the mold will be left clean and sharp. Therefore, in every case where it is possible, all surfaces that occupy a vertical position in the mold should have an allowance for draft. The exact amount of this allowance cannot be given, for in some cases there should be as little as possible, while in others it may be quite considerable without in any way impairing either the purpose or the appearance of the part.

7. Undercut work is the term used to describe the shape of any part or parts of the pattern that cannot be removed from the sand without special arrangements being made for that purpose. Whether any member is to be considered as undercut or not sometimes depends on the position of the pattern in the mold.

A casting of the shape and section shown in Fig. 2 (*a*) and (*b*) is not considered undercut, if it is molded vertically, as here shown and as explained later, but if for any reason this same article should have to be molded in a horizontal position, as in (*c*), the hollows *d* would then make it undercut, as the pattern could not be removed from the mold without carrying away the sand held in the hollows.



(a) (b) (c)

FIG. 2

8. Modeling and Templet Work.—Sometimes it becomes necessary to make the whole or part of a pattern in clay or wax. Such molding is done by hand, and some of the tools used for this purpose are shown in Fig. 3.

When the molded parts constitute plane or circular surfaces, the hand work may be made less difficult by means of templets, mostly in connection with molds in plaster of Paris. This is largely done by drawing templets over the plaster while in a soft condition. These templets are usually made of thin plates of zinc that are cut out to the shape of the molding or whatever is to be formed in plaster. To strengthen and keep the templets from bending, they are backed with wood.

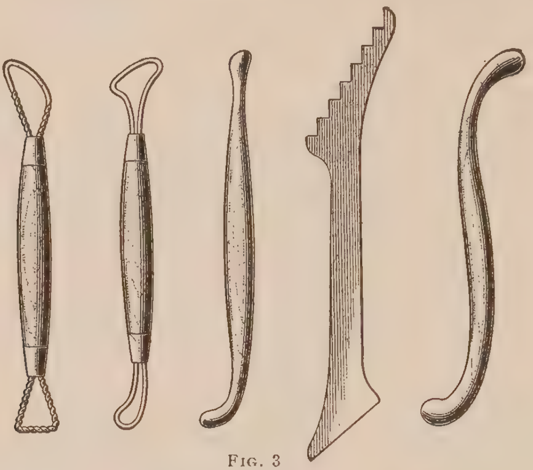
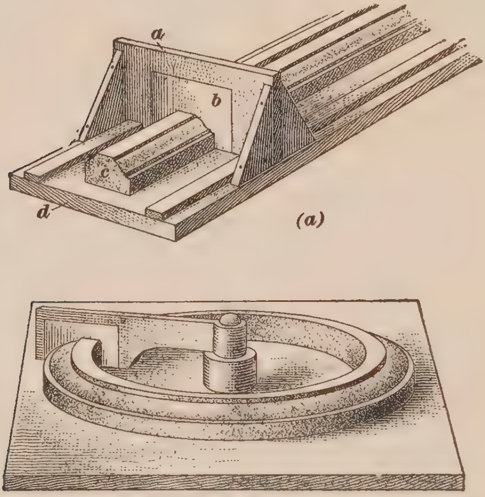


FIG. 3



(a)

(b)

FIG. 4

Fig. 4 (*a*) shows a templet *a* with the zinc part *b* resting on a board *d*. The plaster molding that has to be run up is shown at *c*.

If the molding is required in the shape of a ring, the operation is similar, but the templet is worked from a central pivot, as shown in Fig. 4 (*b*).

9. Shell Patterns.—If the casting is to be made of thin metal, the pattern, which is called a **shell pattern,** is made on a supporting block or bed, sometimes called a *match.* The match, shown in Fig. 5, is made of plaster of Paris *a* and a wooden frame *c*, the latter being used simply to protect the plaster of Paris. The inside of the pattern, which is made of plaster, is shaped on the match with a zinc templet. After becoming hard, the plaster is oiled and varnished, so that the pattern will not adhere while being made. More plaster is then applied and this is swept with another templet made to conform with the outside of the pattern, which completes the model, as shown at *b*. The pattern is then allowed to remain until it has hardened, after which it is removed.

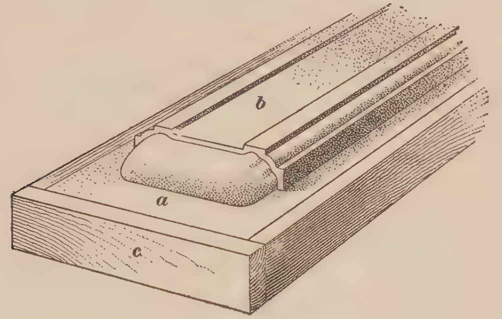


FIG. 5

The match is also used in place of a follow board when a pattern is being rammed in the mold. A pattern, as shown, might possibly be part of the trim around an entrance, in which case the ends would be cut and mitered to form the corners in the same manner as a wooden casing.

10. Patternmaking.—Before describing the process of molding, it is necessary to know more about how patterns are made. A few typical examples will illustrate this in a general way. When the object is of a flat nature, such as a panel or fascia, Fig. 6, the pattern may be either of wood or of plaster.

If there is any ornamental work, as at *a*, the decoration is modeled in clay or wax and then planted on the pattern

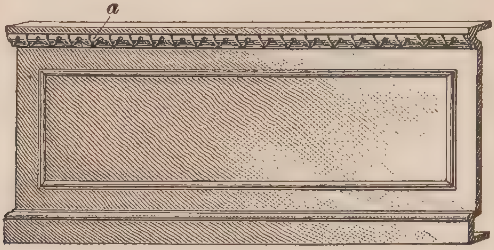


Fig. 6

If the casting is to be hollow, as, for example, the newel post or short column with open ends, shown in Fig. 7, the pattern might be a shell in two halves, joined diagonally and supplemented by a *core box* with which to mold the sand core in order to form the hollow in the finished casting. The making of core boxes will be described further on. In this case, it is assumed that the decoration is in low relief and not undercut. In making this pattern, the body of one-half would be made of wood or plaster and the modeled ornament planted on. From this original pattern, the halves are molded in plaster and used as the working pattern.

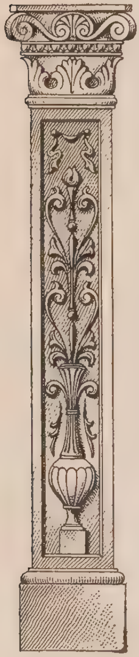


Fig. 7

11. Molding.—The making of molds of various shapes into which molten metal is poured to form different objects is termed **molding.**

The tools used for molding are shown in Fig. 8, and include the rammer with which the sand is pounded into the box and several other implements that are employed to smooth and finish the sand after the pattern is removed. The names of these implements are given in the illustration. The boxes containing the molds, called *flasks*, are made of either wood or iron. In cases where great numbers of similar castings are to be made, iron boxes are preferable. Fig. 9 illustrates an ordinary iron box with toothed cross-ribs, to bind the sand and prevent it from dropping out by its own weight. The pins c, fastened to lugs d_1 on the lower half b, fit into holes in lugs d_2 on the upper half a, thus fixing the relative position of the two halves. When the mold is complete, the two parts are held together with clamps.

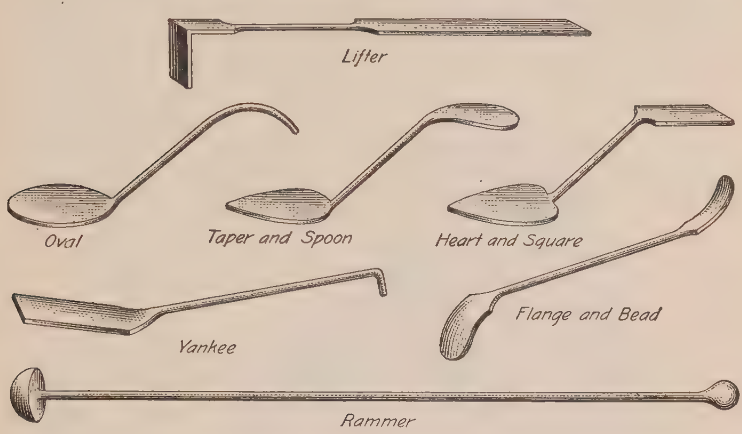


FIG. 8

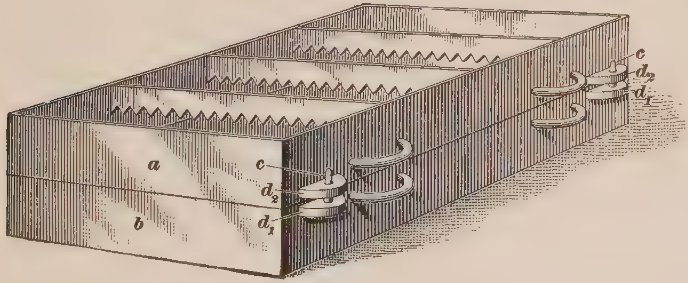


FIG. 9

12. Examples of Molding.—The method of molding a flat panel or fascia, which is shown in Fig. 6, is as follows: The pattern to be molded is first laid face upwards on a board, known as a *follow board*, and then half of the flask, called the *drag*, is placed over the pattern and securely clamped to the board. Sand is then put into the box and firmly tamped down all around the pattern, as in Fig. 10 (*a*). Both box and board are then turned over, as shown in Fig. 10 (*b*), and the board is removed, leaving the pattern uncovered, after which a special dry sand, known as *parting sand*, is sprinkled over the face of the mold. The upper half of the flask, called the *cope*, is now clamped on top and sand is filled in as before, but this time two or more tapered wooden plugs are put in, extending from the pattern to the top of the cope. After the mold is made, these plugs are withdrawn, and the cavities that result make gates and risers for the metal. The top part of the box is next removed and the pattern is withdrawn, leaving an impression of its face in the drag and its back in the cope. The use of parting sand makes the mold separate evenly between the cope and the drag, without disturbing the casting sand.

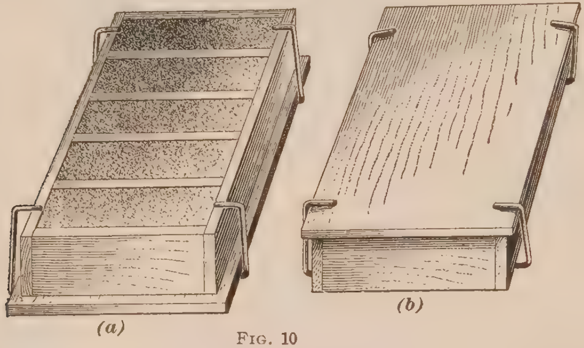

(*a*) (*b*)

Fig. 10

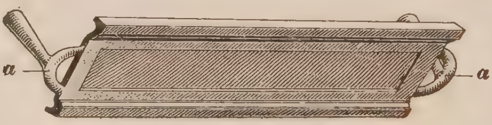


Fig. 11

When a mold is made in the manner just described, there will perhaps be very little finishing to do, but if the sand impressions need any smoothing or alterations, it should be done at this point. The gates or channels for the passage of molten metal are then formed by pulling out the plugs already mentioned. When the metal is poured into the box, it fills not only the space previously occupied by the pattern, but the gates or risers also. The casting will therefore appear as shown in Fig. 11. The gates *a*, *a* are knocked off with a blow from a hammer, after which the casting is cleaned.

13. In Fig. 12, the newel post is hollow and with ornament in low relief. Except in minor detail, the process of casting is the same as that just described. One-half of the pattern is laid on a board, as shown at *a*, and one-half of the molding box *c* is laid over the pattern and on the board *b*. Sand is rammed tightly all around and over the pattern, and the mold is then turned upside down. The board *b* is now removed, and the other half of the pattern is laid in place. The upper part of the molding box is then placed over the lower part and filled with sand around the upper half of the pattern, as before. The top part of the mold is now lifted off and the pattern withdrawn, leaving half of the mold, as shown in Fig. 13 (*b*); but, as the casting is to be hollow, a core will be necessary to form the cavity. This core

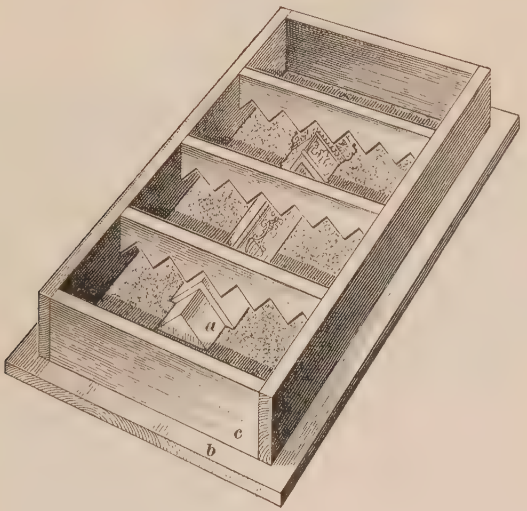
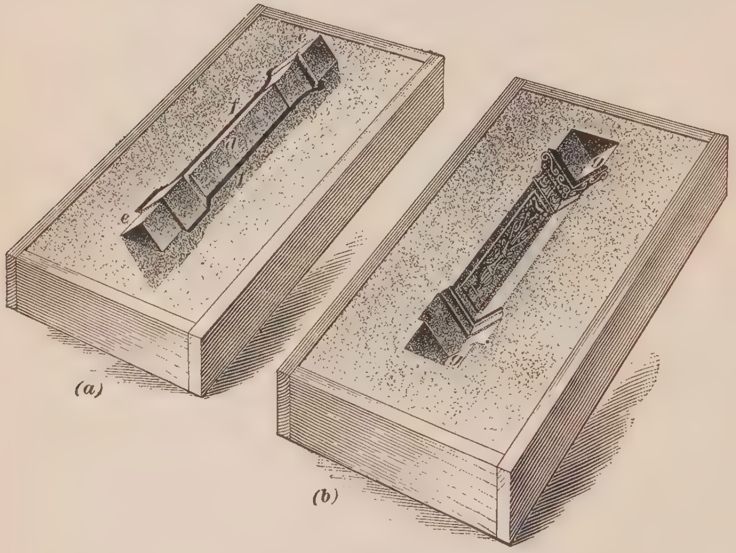


Fig. 12

consists of a block, or bar, of sand the size and shape of the hollow portion, or inside of the casting, as shown at *d*, Fig. 13 (*a*). The core is supported at each end in recesses *g*, Fig. 13 (*b*), formed for the purpose by projections on the pattern called *core prints*. When the core *d* is in place, resting on ends *e*, *e*, the recess *f* shows the thickness the metal will be when the newel is cast. The mold is now ready for casting, if gates have been provided and small holes, called vents, have been left through which the gases may escape.



(*a*) (*b*)

FIG. 13

These gases might otherwise destroy the mold by causing an explosion when the molten metal is poured in. The core being adjusted and the gates formed, the box is closed and clamped as before.

This method of molding is the simplest and is perfectly suitable for any plain casting, but in a more elaborate piece of work, where the ornament is *undercut*, a different method must be resorted to, or the undercut portions, when withdrawn from the mold, will tear out a part of the sand with them. This method will be explained later.

14. Core Boxes.—The molds in which sand cores are made are called **core boxes,** and may be of wood, plaster, or iron, the space in the box corresponding in shape with the core to be molded. In some cases, the pattern is used also in making the core box. As an illustration, Fig. 14 (*a*) is one-half of a pattern from which hollow castings are to be made. It is shown lying on a board with core prints *e e* at each end. This pattern is embedded in plaster or a regular sand mold is made from it. Then a board and roller, Fig. 14 (*b*), are made, the edges of the board being raised equal to the desired thickness of the casting. Soft clay is laid on this board and rolled into strips, with which the sand or plaster mold is lined. Fig. 14 (*c*) shows the mold partly lined. This clay lining adapts itself exactly to the shape of the mold, and if an impression of the lining is taken, a model of the required core will be obtained. From this model can be made another plaster mold, which becomes one-half of the core box. It will look very much like the original mold

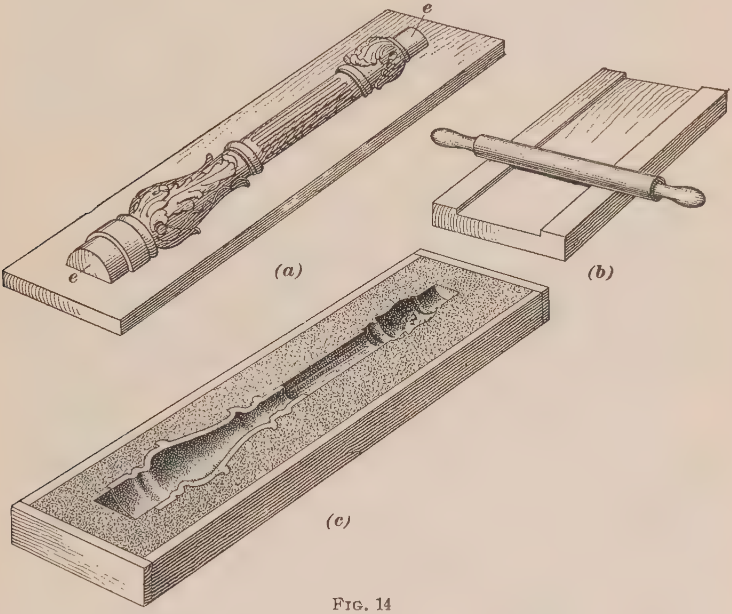


Fig. 14

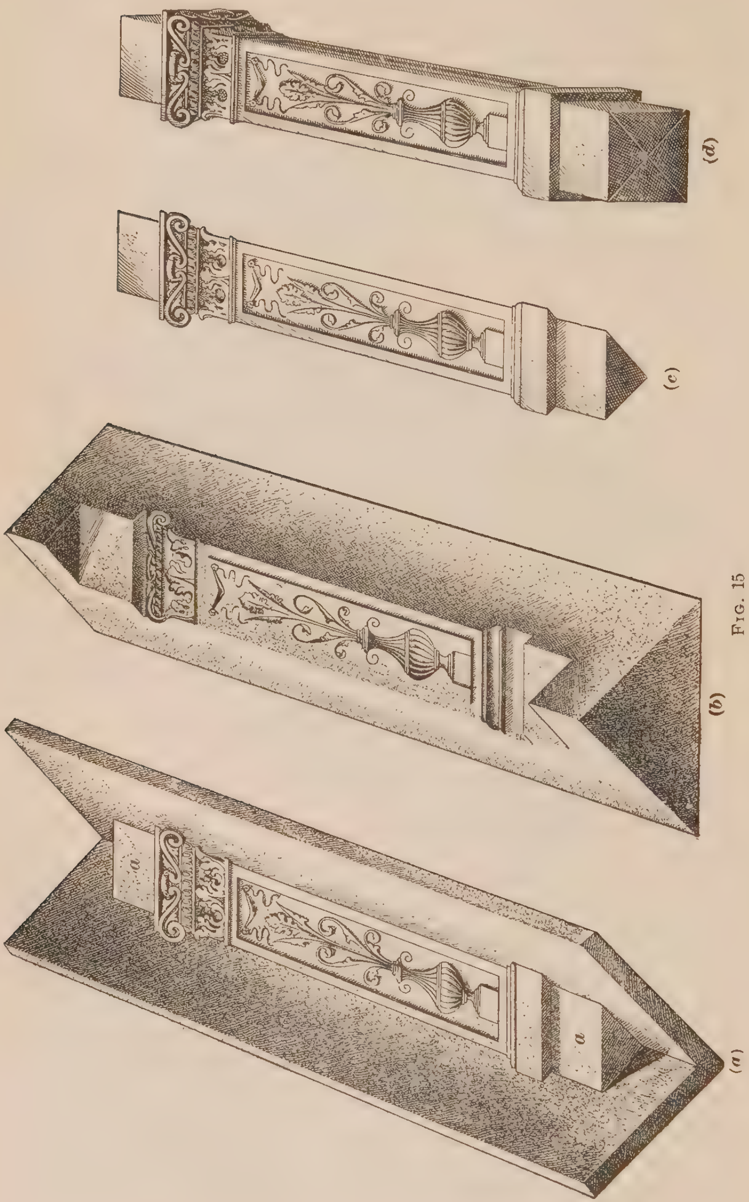
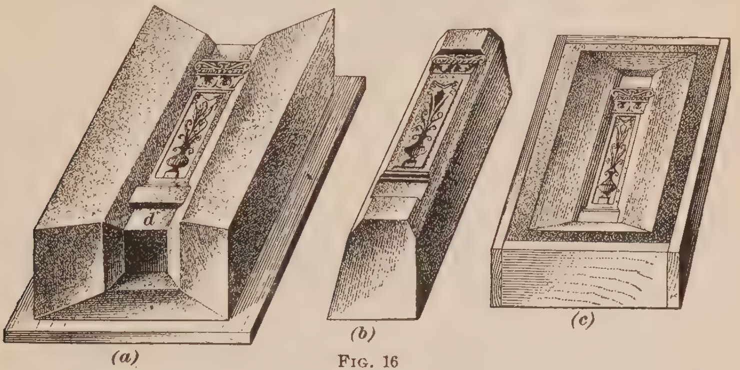


FIG. 15

taken from the pattern, without all the finer details of ornament, but the size of the cavity will be the thickness of the lining smaller, and this, of course, is what is desired.

15. Molding Four-Sided High-Relief Ornate Shapes. If the ornament is very bold, the pattern should be arranged in some other manner, otherwise it will not draw clear of the sand. There are various ways of obviating this difficulty, one being as follows:

Two boards somewhat longer than the required model are fastened together, as shown in Fig. 15 (*a*), forming a right angle, and in this is modeled one-quarter of the pattern with projections *a* at each end to form the core prints. When this model is complete, it is varnished and oiled. A plaster cast is then made by pouring plaster of Paris over the model and entirely filling up the angle between the boards, the result being a solid block with a reverse impression, as shown in Fig. 15 (*b*). This block when dry is used as a mold to produce the four quarters, Fig. 15 (*c*), needed to complete the original pattern. To make these four quarters, plaster is simply poured over the block (*b*), and roughly heaped up to form a ridge; then, by drawing a straightedge against each side of it in turn, the resulting casts are properly mitered, and may be fastened together with shellac, forming a complete model, as shown at (*d*).



(*a*) (*b*) (*c*)

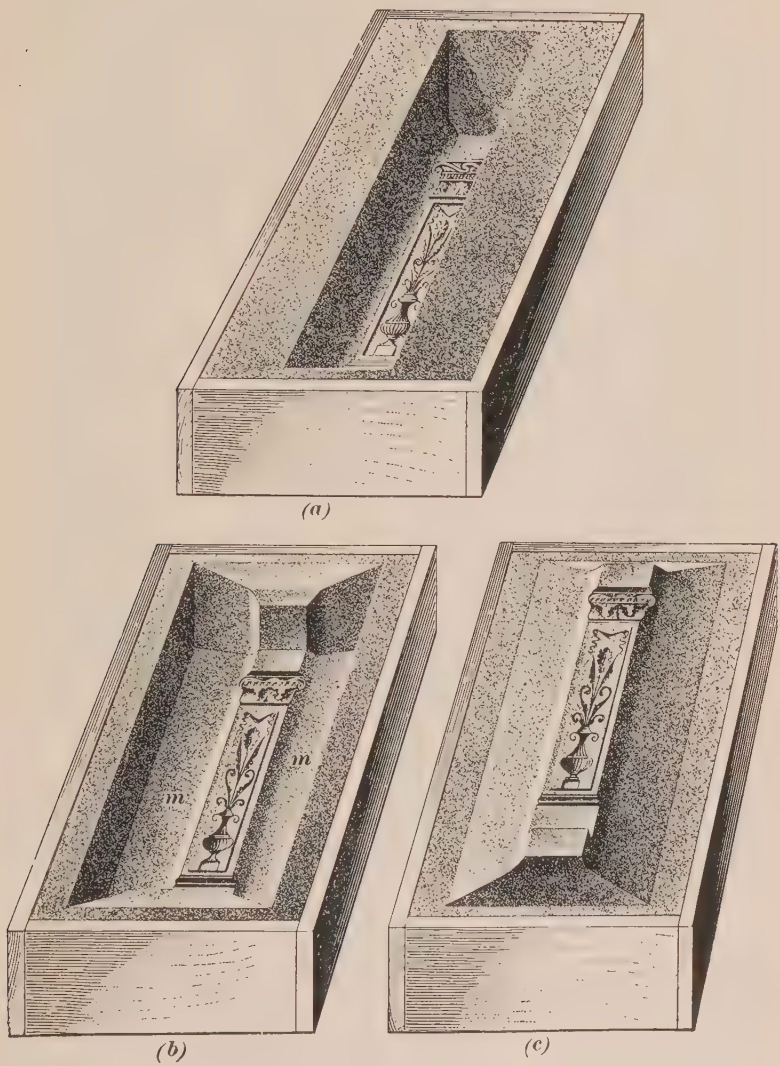
Fig. 16

The model is laid on a board and leveled up, as shown at *d*, Fig. 16 (*a*). The ornament at several points may rest on the board, but the body will be clear. It is then bedded up with clay, sloping the clay from the line of the lower edge of the model gradually down to the level of the board. Then the model is oiled to keep the wet plaster from sticking, and a plaster cast is made of both sides, sloping the plaster upwards to the top edge, and beveling the sides and ends as shown, the object of which will be seen later.

In Fig. 16 (*a*) the model is shown resting on a board, with the two plaster casts of the sides completed and lying against it. These casts, or molds, when detached, appear as shown in Fig. 16 (*b*). A plaster mold is made from each of these blocks. As these molds will be used in the foundry repeatedly, they should have a rough wooden frame to protect them from fracture, as shown in Fig. 17 (*a*).

Two blocks, as shown in Fig. 16 (*b*), are attached firmly with shellac to each side of the original pattern, thus bringing it back to the form shown in Fig. 16 (*a*). The pattern thus treated is ready to be put in the sand and consists of the main part, Fig. 16 (*a*), and the molds for the side parts, Fig. 17 (*a*). The original pieces, Fig. 15 (*a*) and (*b*), are kept only for the purpose of replacing the working patterns in case of accident.

This pattern *d*, Fig. 16 (*a*), is laid on its board and molded in the usual way. When the box is opened and the face of the pattern is brushed off, it will then appear as shown in Fig. 16 (*c*). The upper part of the box is then put in place and rammed up with sand, after which the box is opened and the pattern removed. The mold is left almost wholly in the lower box, as shown in Fig. 17 (*b*), and partly in the upper box, as shown in Fig. 17 (*c*). The plaster mold, Fig. 17 (*a*), is filled with sand, and so is the corresponding mold for the other side, thus making two blocks that correspond in shape and size with the recesses *m*, *m* left in the mold, Fig. 17 (*b*), into which they are carefully slipped. The core is put in place and the molding box is closed. The mold is now ready for the metal, it being understood that gates and outlets have been provided.



(a)

(b)

(c)

Fig. 17

16. The ornament in the example just given, although in such high relief as to preclude the pattern being made as mentioned in connection with Fig. 13, is not really undercut, as any one side could be drawn free from the sand. It is the combination of the four sides, together with the bold ornament, that necessitates the peculiar arrangement of the pattern. There are other means of reaching the same result, such as making the ornaments on two sides of the pattern detachable, so that after withdrawing the main part, or body, these loose pieces are left in the mold and can be picked out separately.

17. Undercut Work.—In undercut work, this latter method of making the ornament separate, to be picked out after the main part of the pattern has been drawn, is sometimes successful. The following will explain more fully what is meant by **undercut work** and how the patterns are adapted to meet the difficulty. Fig. 18 (*a*) shows a plain, flat square, or rectangular slab, with a vertical rib on the under side. It is evident that any such article may be molded in the ordinary way, as the entire pattern can be drawn straight upwards in the direction of the arrows, as at (*b*). Now, suppose that the rib is inclined at an angle, as shown at (*c*); the conditions are changed so that the pattern cannot be drawn in the same manner as in the previous case. The obvious solution of the difficulty is to make the pattern

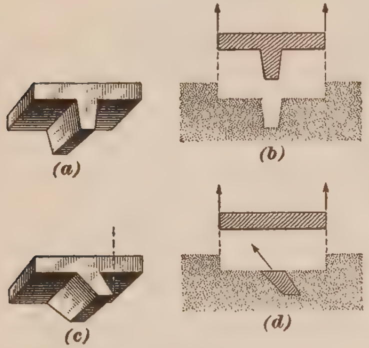


FIG. 18

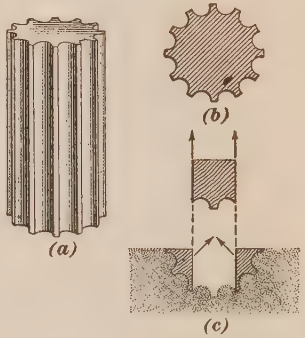


FIG. 19

in two pieces. Then, the upper section can be lifted vertically, leaving the rib to be drawn subsequently, as indicated by the single arrow in (*d*).

A somewhat different case is shown in Fig. 19 (*a*), being part of a fluted shaft, a section of which is also shown at (*b*). It will be seen that if this pattern were made in one solid piece, or even if the pattern were in halves, and had sand packed all around, being cast on its side, it would be impossible to get it free without breaking up the mold. The pattern should be divided into halves, and each half subdivided as shown at (*c*). Then, the middle section can be drawn straight upwards, and each of the side sections may be drawn inwards sufficiently far to clear the sand before being lifted out. In both of these cases, the result is gained by using loose pieces, or, in other words, by subdividing the patterns.

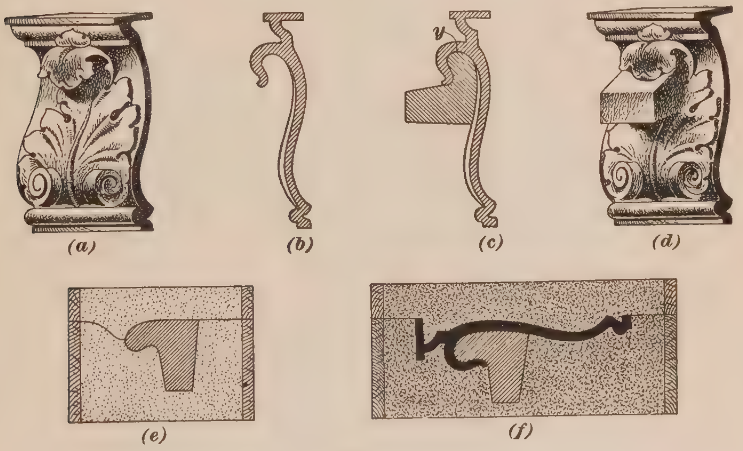


Fig. 20

18. Fig. 20 represents an example where other methods must be employed. The upper part of the foliage overhangs and forms a deep undercut hollow. At (*a*) is shown the original model, which is of clay, and (*b*) shows a section through the middle of the leaf. In order to get a working pattern, the model is laid flat on its back and plaster is poured into the hollow of the leaf so as to form into a square piece that will project outwards, as shown in section at (*c*) and in perspective at (*d*). This piece is called a *point.* At this stage, the whole model is turned over and plaster is poured over the back of it, forming a solid bed, or match. It is now required to separate the plaster point from the model. To do this, the top of the leaf at *y*, Fig. 20 (*c*), must be cut or broken away. Next, a plaster mold is made of this point, as at (*e*), and when this is done the point is replaced on the model and the top of the leaf is fixed in place again.

The model thus prepared and lying on its bed is covered with the molding box and the sand is "rammed home." The whole is then turned over, the block removed, and a sand mold made of the reverse side of the model. This half of the mold is lifted off, and the model is drawn (which can be done freely, since the hollow of the leaf is filled up by the plaster point). Meanwhile, a sand impression of the point has been made from its plaster mold, and this impression, or *core*, as it would be called, is dropped into its place in the space left for it by the plaster point in the sand mold, as at (*f*). The proper gates and vents being provided, the casting can now be poured. If the ornament should chance to be undercut at the lower part of the leaf also, additional points would be made in the same way.

19. In the process of casting, it is not good practice to have heavy pieces cast adjacent to much lighter ones. As the lighter parts cool very quickly compared with the heavy portions, the result would be disastrous, owing to the unequal shrinkage of the metal. Thin pieces shrink in a very short time, and in doing so are liable to crack away from the thicker parts, which retain the heat longer and consequently do not shrink so rapidly. These remarks should not be taken to mean that every casting must be of exact thickness throughout, but where there are variations of this kind adjoining, thick and thin sections should be graded together gradually, avoiding as much as possible any very abrupt change from one to the other.

A casting designed without regard to this matter may be molded successfully and in some cases the unequal shrinkage of the parts may be avoided by opening the box as soon as the molten iron has had time to solidify and thus exposing the thick portions to the atmosphere, while the thinner parts remain covered with the sand, in order that they may retain the heat for a longer period and thereby somewhat equalize matters. Even then there would be a certain amount of latent strain left, which would likely be sufficient to cause a subsequent fracture should the casting be subjected to a sudden jar or impact.

Having thus far described the use of iron as a medium for decoration and the processes generally used for cast-iron patternmaking, molding, and casting, the different structures and parts generally made of iron will now be considered.

STRUCTURAL DETAILS

20. Screws and Bolts.—In Fig. 21 (*a*) is shown what is termed a *square-head bolt*. Bolts of this kind are used for all common connections, such as the joining of two flanges or other surfaces that are not exposed to view. At (*b*) is shown a *screw-head bolt*, which is used for work where a countersunk head is necessary in order to obtain a smooth surface, the slot in the head being filled with putty after the work is in place. At (*c*) is shown a *countersunk-head bolt*, used for the same purpose as a screw head, and also for securing wooden stair treads to wrought-iron strings, so as to permit the head to finish flush with the tread. The countersunk-head bolt is also used in joining flat surfaces where a smooth finish is required.

At (*d*) is shown a *tap bolt*. This bolt is used for all connections where it would be impossible to get a nut on the end. The hole into which this bolt is to be screwed has a thread cut in it, or is "tapped," as the technical phrase would express it. At (*e*) is shown a *countersunk tap bolt*, which is used for joining very heavy work that requires a smooth-finished surface. After the bolt has been tightened up by the aid of a wrench, the square head is cut off.

Lagscrews, shown at (*f*), are used to fasten iron to stonework or woodwork; a plug of soft metal or wood is driven into a hole drilled in the stonework, and the screw is inserted into this plug.

At (*g*) is shown a *double-expansion bolt*, used for fastening work to brick or stone walls, and consists of a threaded bolt

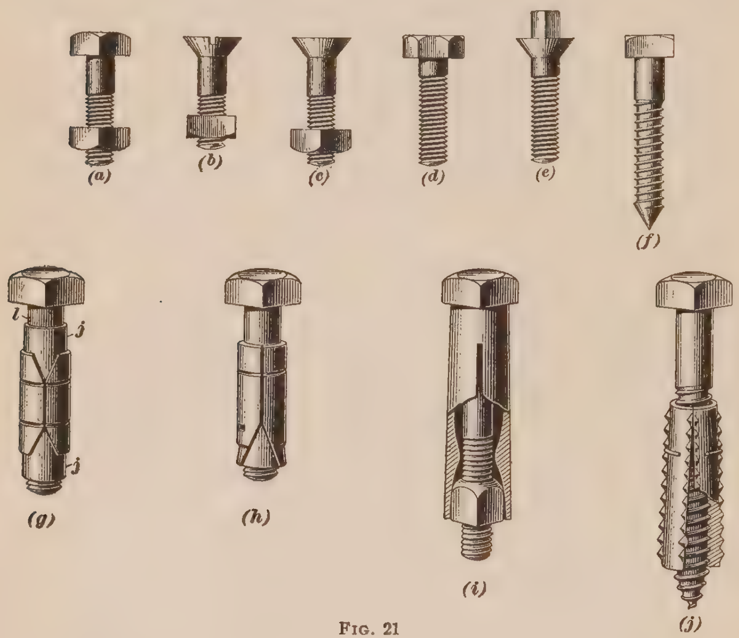


Fig. 21

and an expansion shell into which the bolt screws. In using these bolts, the shell is first inserted into the hole made for it and the bolt is screwed into this. As the bolt *l* advances against the object to be fastened, the parts at *j*, *j* are pushed together, gradually spreading the shell and causing it to firmly grip the sides of the hole. The *single-expansion bolt* (*h*) acts in the same way, and is used for the same purpose. The chief advantage of these bolts is that they may be taken out without damaging the surrounding stonework or brickwork. At (*i*) and (*j*) are shown two other types of expansion bolts; the shell on (*j*) is often made of lead, which accommodates itself very closely to the surface of the hole as the bolt is screwed up. Expansion bolts are also made with screw heads, for use where the surface will be exposed to view.

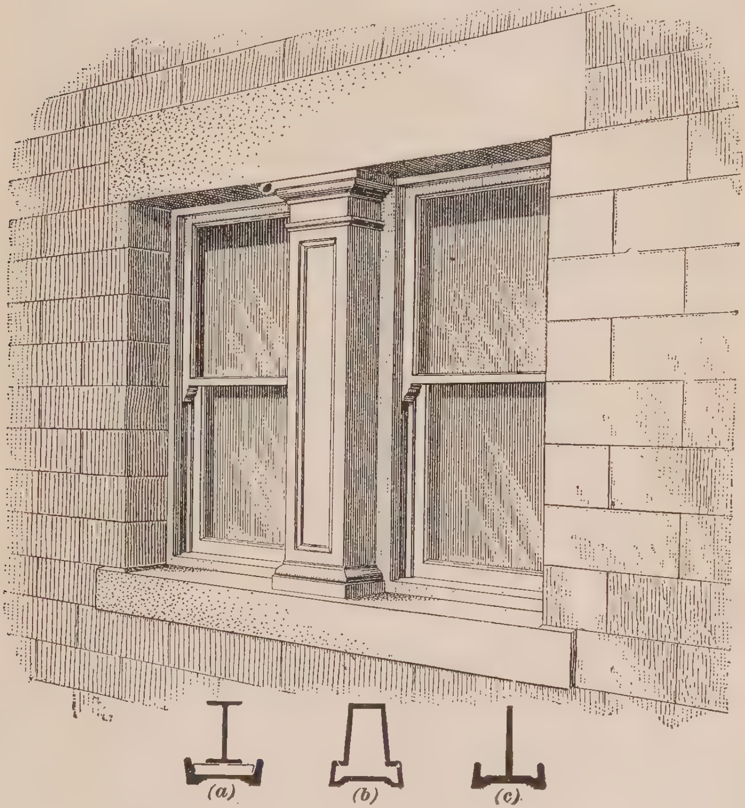


Fig. 22

21. Mullions.—A window such as shown in Fig. 22 is sometimes so wide that it requires a mullion, and the design of this mullion must be consistent with the rest of the building, no matter what its construction may be. In Fig. 22 is illustrated three ways of constructing such a mullion: (1) with an upright I beam and cast-iron facing, as shown in plan at (*a*); (2) with a cast-iron box on which the ornament is cast, as at (*b*); and (3) a modification of these two, which consists of a **T**-shaped casting with the ornament on the face, as at (*c*). The advantage of the first method is that the ornament may be applied without regard to the structural support, while in the other two, sufficient allowance must be made in the thickness of the metal to proportion the support to the load.

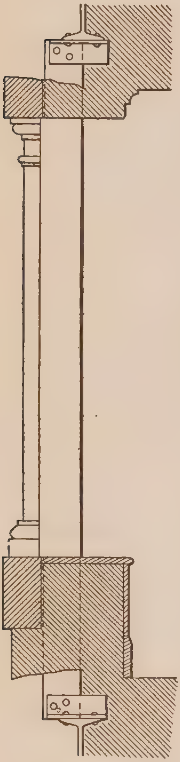


FIG. 23

In the first example (*a*), the cast-iron facing is screwed or bolted to the **I** beam. The decoration may be a simple panel, as shown, or a highly ornamented arabesque, according to the requirements of the design, for so long as the sides are plain, the casting of the mullion presents no particular difficulty, being only a plain panel, the pattern for which would be of wood about ½ inch thick with the sides slightly beveled or drafted to allow it to be drawn freely from the mold.

The length of the mullion is 8 feet; therefore, the pattern should be 8 feet and 1 inch in length, to allow for shrinkage.

If the design of the mullion is ornamental, the pattern may be entirely of plaster, or the body of wood and the ornament modeled in clay. If there are to be a number of these mullions in the façade, only one model is made; and, by covering this with plaster of Paris, a mold is obtained from which any number of wax duplicates can be cast of the original, which are then mounted on the body of the pattern for the mullion.

In the second case (*b*), the pattern should be made in a similar manner to (*a*), but, in addition, a core box is necessary, in which the sand core is made to be placed in the mold so that the desired thickness of metal is obtained. The sides of this mullion are checked or rabbeted to receive

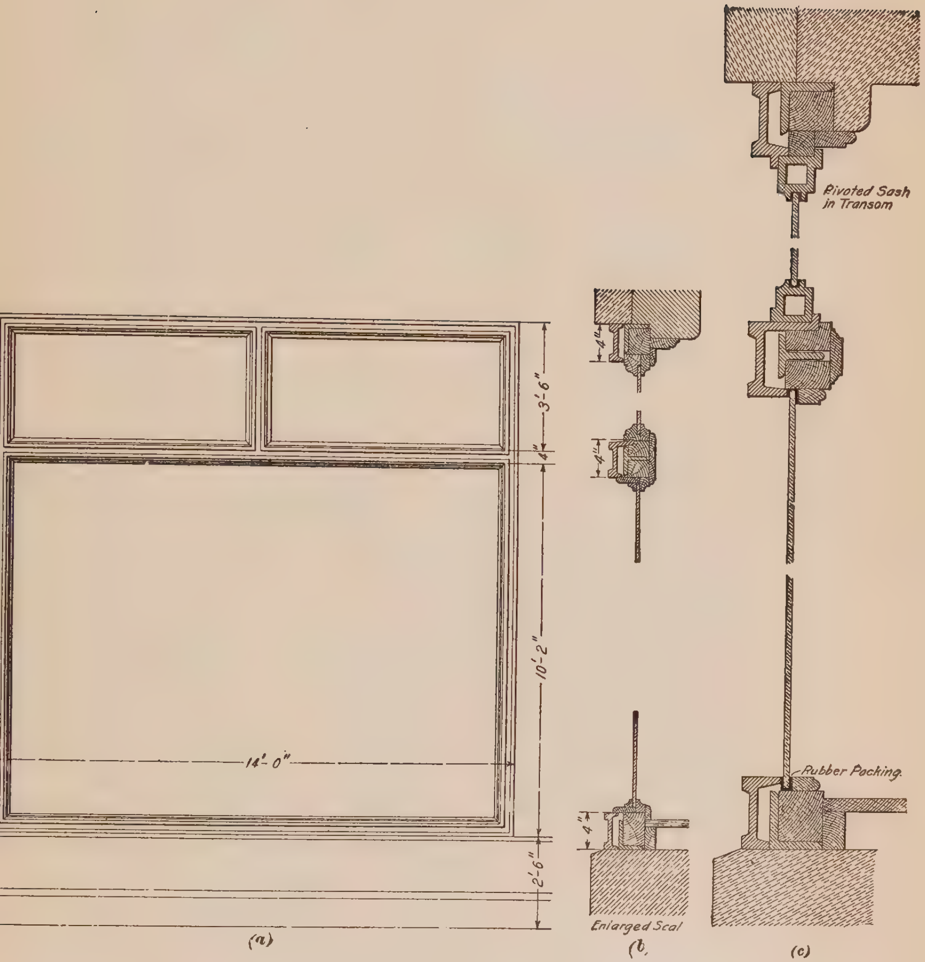

Rivoted Sash
in Transom
4"
3'-6"
4"
4"
10'-2"
14'-0"
Rubber Packing
4"
2'-6"
Enlarged Scal
(a)
(b)
(c)

FIG. 24

the window frames, while in (*a*) and (*c*) the frame passes back of the reveal or side of the mullion.

The third case (*c*) should only be used where the superimposed load is small; its chief advantage lies in the fact that it does away with the use of the **I** beam without requiring a core for the casting, thereby saving both in the cost of manufacture and in the setting.

Mullions are sometimes set in between the sill and the lintel and fixed thereto, but in fireproof buildings with beam construction, a better plan is to run the back member, or web, of the mullion from beam to beam, so as to bind it securely to the framework of the building. Fig. 23 is a side view of a mullion fixed in this manner.

22. Window Frames.—Cast-iron window frames are sometimes designed as mere outer protection for the real wooden frames, as shown in Fig. 24 (*a*) and (*b*), where the ironwork is made after this fashion. This arrangement occurs mostly in show windows, and may be decorated as desired. The sash above the transom bar may be pivoted at the sides, so as to swing open for ventilation. Fig. 24 (*c*) is a vertical section of a similar window with no woodwork exposed to the action of the weather, the transom sash in this case being of metal. There is a structural frame of angles and tees with their ends built into the brickwork or fastened with expansion bolts, whichever is most expedient. To this frame the outer ironwork is screwed or bolted.

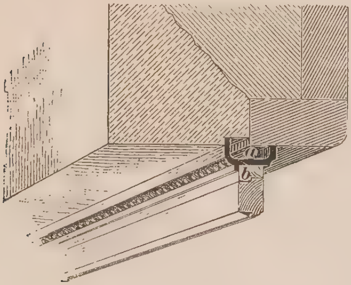


Fig. 25

This class of window is also framed as shown in Fig. 25, where the section of the window sorfit shows a cast-iron frame, the outer edge of which takes the place of the weather stop and is ornamented with an egg-and-dart molding. The section of the iron jamb and head shown at *a* may be used for either a stationary window set directly in the iron frame or a French sash window, the hinges of which are secured to the iron frame with countersunk tap screws; or, when a wooden hanging stile is introduced, as shown at *b*, a pivoted sash may be used. The decoration of the weather stop and the inside of the frame should conform to the general design of the building.

The pattern for the body of the frame would be modeled in wood, and the decorated parts would be done in clay, cast in plaster, and applied to the body of the pattern. The outer and inner faces of the frame should have considerable draft, so that the casting may be easily withdrawn from the mold.

23. Although vertical sections are given in the preceding illustrations, they are by no means working drawings, and in order to show how this kind of work is prepared for the shop, examples are given in Figs. 26 and 27.

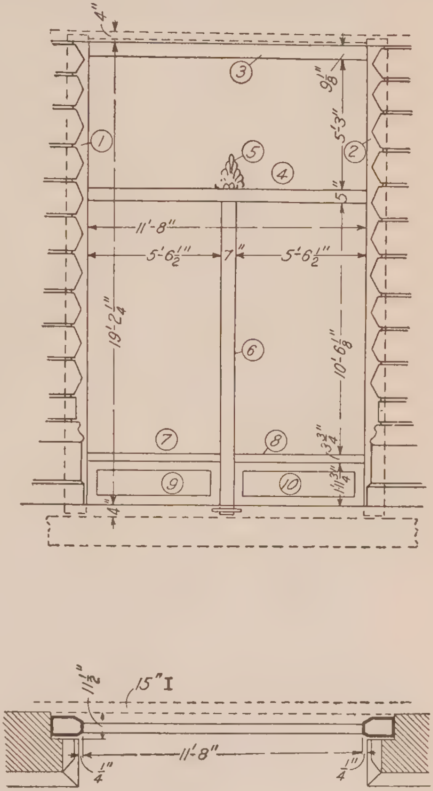


FIG. 26

Fig. 26 shows a block elevation and plan, or horizontal section, of an iron window frame, the sash of which is to be of wood. The various pieces are few in number and simple in design. Before commencing to lay out the working drawings of the ironwork, it is assumed that the stonework surrounding the opening is either already built or has been

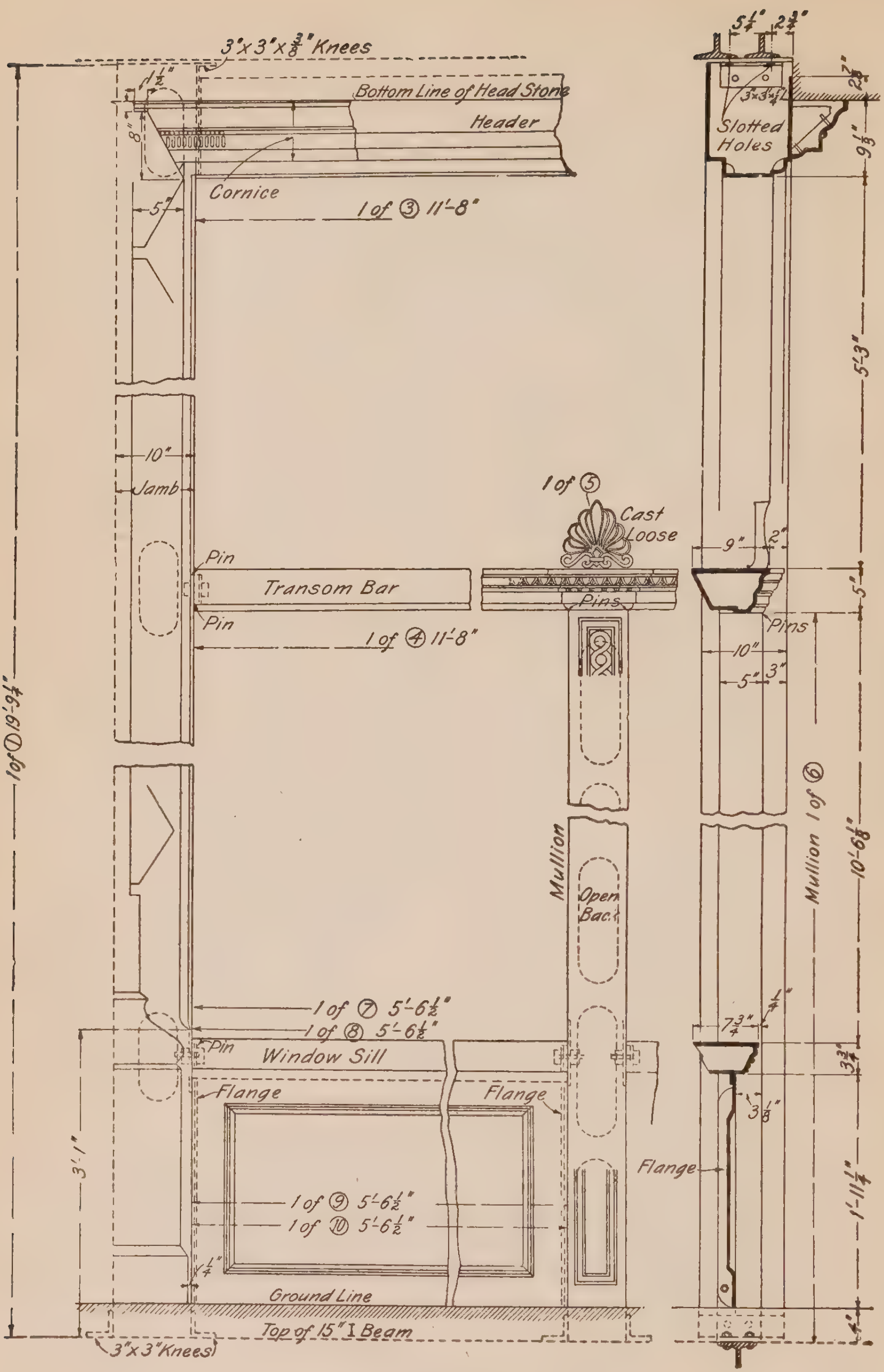

3"x3"x3/8" Knees
1 1/2"
Bottom Line of Head Stone
Header
8"
Cornice
5"
1 of ③ 11'-8"
10"
Jamb
1 of ⑤
Cast Loose
Pin
Transom Bar
Pins
Pin
1 of ④ 11'-8"
Mullion
Open Back
1 of ⑦ 5'-6 1/2"
1 of ⑧ 5'-6 1/2"
Pin
Window Sill
Flange
Flange
3'-1"
1 of ⑨ 5'-6 1/2"
1 of ⑩ 5'-6 1/2"
1/4"
Ground Line
Top of 15" I Beam
3"x3" Knees
1 of ① 19'-9 1/4"
5 1/4"
2 3/4"
2 7/8"
3x3 1/4 L
Slotted Holes
9 1/3"
5'-3"
9"
2"
5"
Pins
10"
5"
3"
Mullion 1 of ⑥
10'-6 5/8"
1/4"
7 3/4"
3 3/4"
3 1/8"
Flange
1'-11 1/4"
4"

Fig. 27

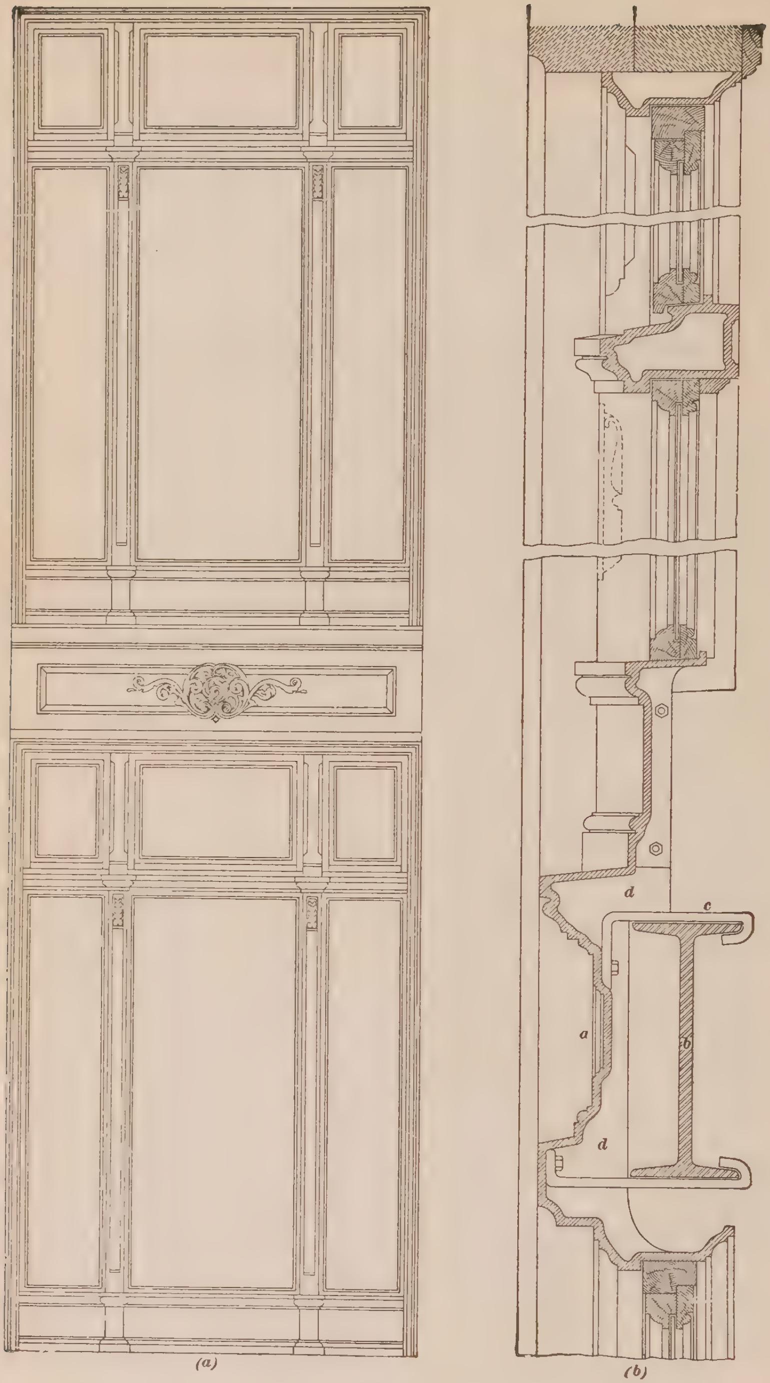
definitely decided on, so that the measurements may be obtained. These measurements being secured, the ironwork should be drawn full size for the information of the patternmaker. From the full-size drawings, it is an easy matter to draw the scale details necessary for the fitter and erector.

Usually, the molder does not need working drawings, as he gets his order for so many pieces to be cast from the pattern as they are handed to him. The fitter, on the other hand, should have scale details showing how the work is to be assembled, and the same applies to the erector, the full-size drawing being too unwieldy for general use. On the block elevation and plan, Fig. 26, are marked the general sizes and piece numbers of the parts, and on the larger detail, Fig. 27, is given fuller information, together with the quantity required of each casting with its corresponding piece number. The latter drawing also shows the construction of the whole, and should be supplemented by a written schedule, or list, of every piece entering into the composition of the completed work.

24. There is practically no limit to the use of iron as building material, and in many of the modern office buildings and hotels one of the principal features of the architecture is the long window bay running through half a dozen or more stories as shown in Fig. 28 (*a*). These may be constructed either entirely of iron or with iron frames and fascias, the sash being of wood or some light metal.

The section, Fig. 28 (*b*), shows the frame, transom bar, and fascia. Behind the fascia *a* is the floor construction with probably a beam, or girder *b*, to which the fascia is attached with hooks and bolts *c*, of whatever shape may be most expedient. Ribs *d*, *d* are cast at intervals on the back of the fascia, so as to bear against the top and edges of the beam. The hooks, or clamps, are made of the size and shape to suit the position they are to occupy.

The upper part of such a series of window bays surmounted by an imposing balcony is shown in Fig. 29. This



(a) (b)

FIG. 28

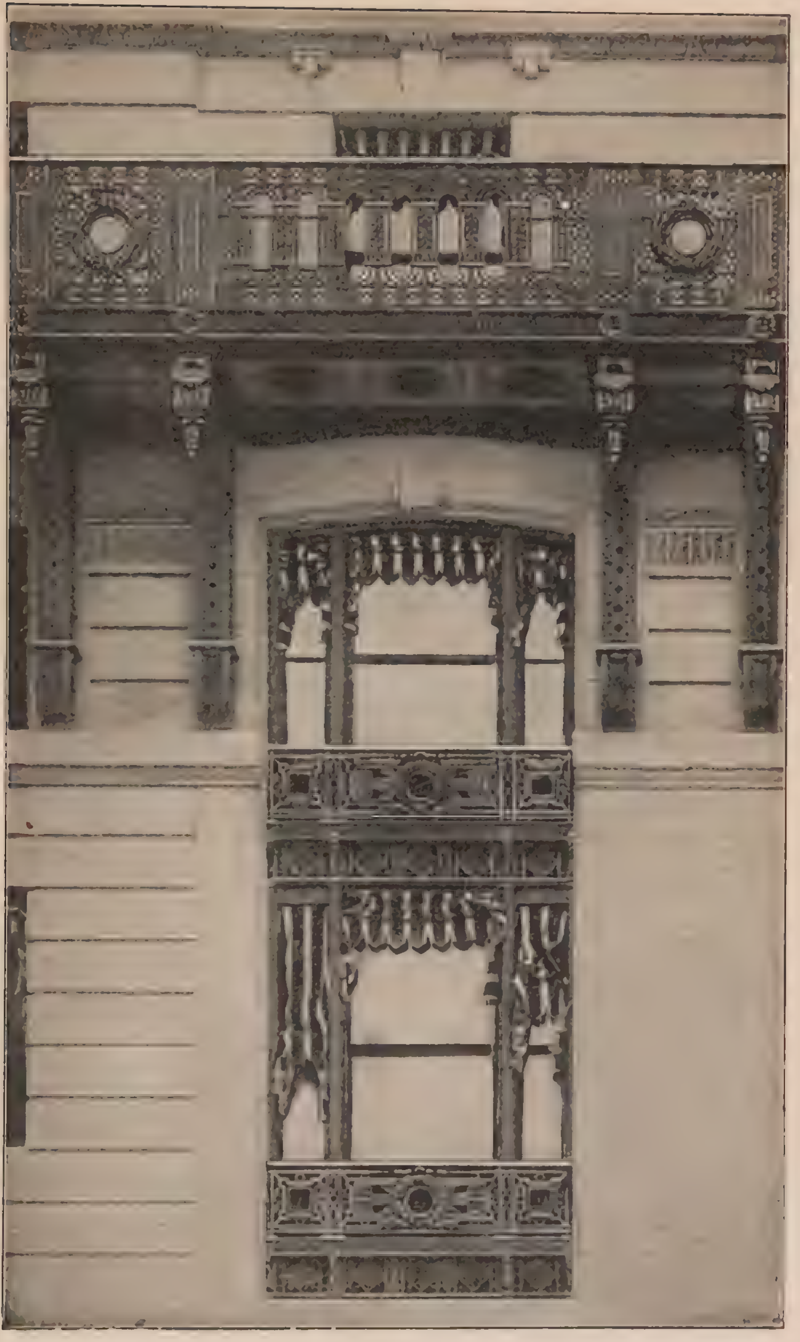


FIG. 29

particular design is an excellent example of the successful application of ironwork to building construction.

25. It frequently happens that the window-frame casting includes the outside casing and molded reveal, as in Fig. 30, which shows a richly ornate soffit. In this case, the reveal of the soffit *a*, or the jamb at the side of the opening, is first set, then the frame *b* is put in place, and last the casing, or architrave, *c*, the head of which is checked into the stonework. In the modeling and casting of these pieces the architrave *c* has the rosette ornament and reveal *b* has a repeating ornament both of which are molded and cast separately. By this procedure, only one model is required for the rosette and one for the repeating ornament, and castings from these are taken until the required quantity is obtained. Thus, in case of a failure in casting the ornament, the entire casting of the soffit or architrave is not made worthless, as it would be if the ornament were cast with the main detail in one piece and a portion of the ornament proved defective.

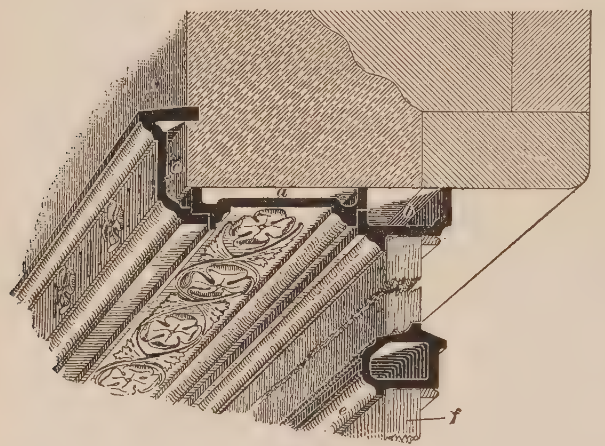


FIG. 30

26. Door Frames.—As a rule, when cast iron is used for a door frame, it is more properly a jamb and architrave, though in some cases the door frame itself is of iron, the same as a window frame, and the hinge butts are secured directly to it, unless a wooden frame has also been provided. The design shown in Fig. 31 is the soffit of a simple molded jamb and architrave, the wooden-door frame being fitted against it. Both the jamb and the architrave are secured to the stonework with expansion bolts, and the joints are bolted together with countersunk screw bolts. In designing a door frame, two chief points to bear in mind are the draft and the proper location of the joint between the two pieces. All joints of this character should be specially designed and so placed that they may form a practically invisible meeting line between two moldings, as shown at *a*. In very large work, and in buildings that are entirely of iron construction, it is better to set up, 2 feet apart, a series of 2″ × 2″ angle-iron jamb pieces to which the door jambs may be bolted; the inside ends of the latter have knees to which the door frame proper is bolted. The architrave should also have an angle-iron frame set up against the stonework and secured with expansion bolts, and the architrave should be fastened to this with countersunk screw bolts.

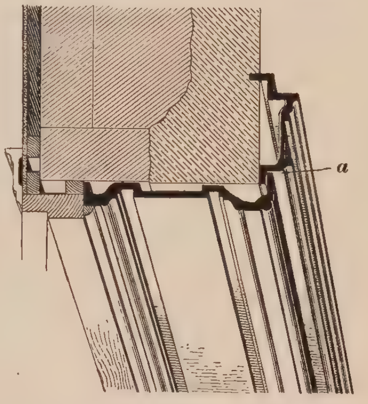


FIG. 31

27. Drawings for Window Frames.—The series of drawings shown in Fig. 32 illustrates a combined entrance and show window. With the exception of the full-size details, which cannot be reproduced here, this series forms a complete set of working, or shop, drawings. The general design of the ironwork is in harmony with the building of which it forms a part, and the details are worked out piece by piece in proper relation to each other and to the whole.

After the design is made, and before the work is detailed, it is necessary: (1) To measure the brick piers and the width of the whole opening between them; (2) to get the height from the first floor level to the under side of the girders overhead; (3) to note the exact position of the beams and girders at the ground level, together with their sizes; (4) to find the various levels of the sidewalk and the inside floor, and in fact to collect all information pertaining to the stonework, brickwork, and structural ironwork to which the ornamental work of the entrance and show windows is to be connected.

Having obtained all the data, and having the design already prepared, the working out of the details should proceed naturally. First comes the plan, Fig. 32 (*a*), which, like most plans in architectural drawings, is really a horizontal section; next, the plan, Fig. 32 (*b*), through the upper part of the show window; and then the front elevation, Fig. 32 (*c*), and the various sections (*d*), (*e*), (*f*), and (*g*).

The space left between the brick wall and the iron panel on the one side and between the adjoining building and the furring blocks on the other side is for pipes, otherwise the iron panel might have been set back close to the brickwork.

These drawings should be made in the order given, but as each one is so intimately allied to the other, it will be found that the details of construction will work themselves out as a whole. For instance, the facing of the piers and the plates and panels of the vestibule will be determined in relation to the height and width of their parts, as shown by the elevation and sections, so that as the drawings progress there will be a constant reference from one to the other. It should be borne in mind, however, that most of this work is drawn full size, and that scale details are merely smaller reproductions of the large drawings made in a convenient size for the use of the artisans in assembling, fitting, and erecting the work.

The reasons for putting up any structure are as varied as are the designs of the work. When it is remembered that there is practically no load to be supported and that the position of the joints are determined to a great extent by considerations of convenience, there can be no fixed rule in regard to this matter. To be successful, a knowledge of molding is indispensable, in order to avoid bent and twisted castings. A careful examination of these drawings is better than any written explanation.

28. An excellent exercise is to make a complete schedule of this entrance and window, drawing each piece separately, both front view and section, and identifying it by its number (shown in the details enclosed in a circle). The result will be a very thorough understanding of the whole subject.

The pieces are numbered as follows: Cornice, *1*, *2*; frieze, *3*, *4*; dentils, on cornice, *5*; trim over window, *7*; trim around vestibule, *8*, *9*, *10*; trim at side of window, next pier, *11*, *12*; pilasters, *13*, *14*, *15*; ceiling, *16*; vestibule panels, *17*, *18*; consoles, *19*, *20*; soffit, *21*; mullions, *22*, *23*, *24*, *25*, *26*, *28*, *29*; sill, *27*; base panel, *30*; gutter, *32*; cornice, *33*, *34*, *35*; cartouch, *36*; base, *37*, *38*, *39*; various channels, angles, etc., *40*, *41*, *42*, *43*, *44*, *45*, *46*, *47*, *48*.

There are a few additional small pieces, such as angle knees and plates, which are attached to the larger parts, and belong to them. These are not distinguished by separate numbers.

STAIRS

STRAIGHT-RUN STAIRS

29. Stairways.—The stairways in public buildings should be of iron, and by reason of the prominence of their location, it is usually necessary that their design should be in accordance with their surroundings. A number of stairways are herein shown, not to give a variety of examples, but to illustrate the different conditions that are likely to arise. Any of these designs may be stripped of its ornament and be used in the plainest structures, or the ornament may be increased and the design made suitable for a most elaborate interior.

The stairs shown in Fig. 33 are suitable for such use as a basement stairway or in a place where two floors are leased or used by one occupant and communication between them is necessarily independent of the public halls and stairs.

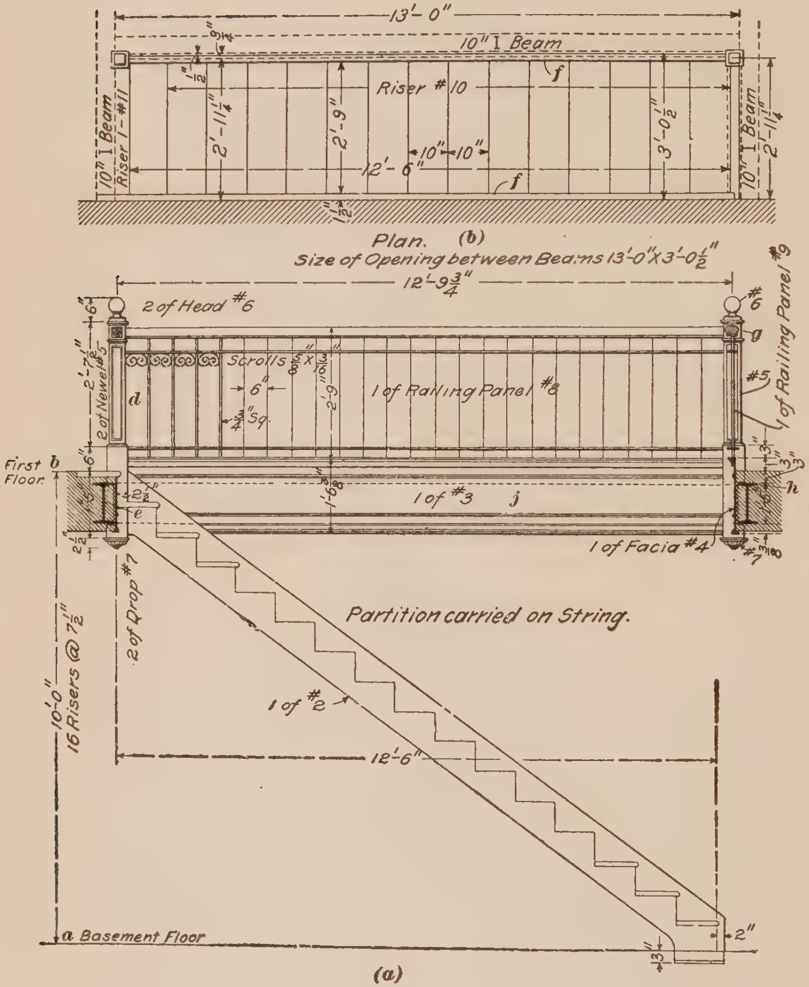

13'-0"
10" I Beam
3/4"
1/2"
Riser #10
f
2'-11 1/4"
2'-9"
3'-0 1/2"
10" I Beam
Riser 1-#11
10"
10"
12'-6"
f
10" I Beam
2'-11 1/4"
1/2"
Plan. (b)
Size of Opening between Beams 13'-0" X 3'-0 1/2"
12'-9 3/4"
2 of Head #6
#6
g
6"
2'-7 1/2"
2 of Newel #5
Scrolls 5/8" X 3/16"
6"
3/4" Sq.
d
2'-9"
1 of Railing Panel #8
#5
1 of Railing Panel #9
6"
3"
3"
First Floor
b
2 1/2"
e
1'-6 3/8"
1 of #3
j
h
2 1/2"
1 of Facia #4
#7
3 3/16"
2 of Drop #7
Partition carried on String.
10'-0"
16 Risers @ 7 1/2"
1 of #2
12'-6"
a Basement Floor
3"
2"
(a)

FIG. 33

30. In laying out the drawings for the flight of stairs shown in Fig. 33, locate the center line of the newel *d*, 1 inch from the face of the beam *e*, and the face of the last riser at the center of the newel, and from this riser measure off 15 × 10 = 150 inches (there being fifteen treads), which will be 12 feet 6 inches and there locate the position of the face of the first riser. The framed opening of the well through which the stair is raised is more than the length of the stair, so that the headroom does not necessarily have to be considered. The width of the opening is 3 feet. The rise, the tread, and the position of the newel, the first and the last riser, and the width of the opening being fixed, a plan, as at (*b*), should be laid out, then the section (*a*), which shows the inside face of the string that finishes against the newel. The next point to consider is the finish of the well; this, as shown in the section (*a*), has a molded fascia *j*, a light hand rail of wood, a balustrade of wrought iron composed of $\frac{3}{4}$-inch square balusters with a top and a bottom rail, and two additional rails forming a frieze and dado through which the balusters pass, making a very stiff balustrade. The center line of newel *g* and the end rail are set 1$\frac{1}{4}$ inches from the flange of the beam *h*. These points being fixed, the general layout is complete and the next procedure is to make the several parts in detail. It will be observed that the section (*a*) is drawn looking toward the railing.

31. The first piece to detail is the string *f*, the sectional shape of which is shown at *i*, Fig. 34 (*c*). The lug *k* is cast on the string, and supports the ends of the treads. The head of the outside string is cast with the base, or lower part, of the newel on it, and is shown in plan at *d*, Fig. 34 (*b*), and in elevation at (*a*). The plan (*b*) shows a lug *l* cast on the back of the newel that holds the string in place, and is secured to the flange of the beam with a hexagonal-headed bolt; the lug *m* is cast on the inside of the newel to receive the last riser.

On the right side going down, the string is bolted to the solid brick wall with expansion bolts, but on the bottom of the left-hand string there is a solid plate with braces, as at *u*, Fig. 34 (*c*). This plate carries the fire-block partition on that side of the stair. Instead of a partition there might be a piece of open grille-work between the top of string and the floor above, and in that case the string would have no bottom plate but would be molded or ornamented on the outer face. The object of having a solid partition is that

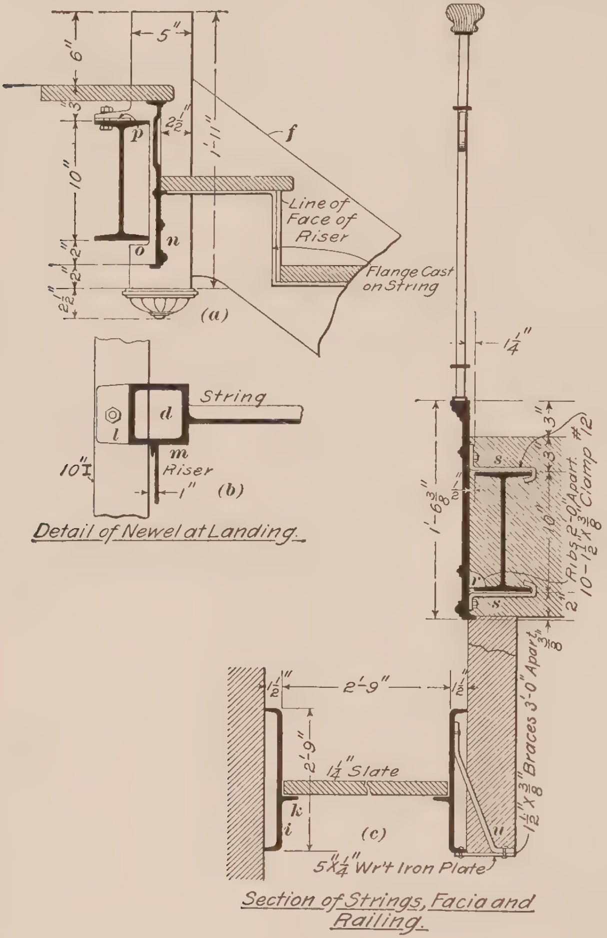


FIG. 34

the lower story may be shut off from the upper story, a door also being placed at the foot of the stairs for this purpose.

At *o* and *p*, Fig. 34 (*a*), a small allowance is made for any variation that might arise, thus enabling the erectors to raise or lower the stairs a fraction of an inch in case of necessity.

The angle newel is secured to the beam in the same manner as the newel *d*, and is cast with two lugs, so as to receive both the end and the side fascias. These fascias are cast with ribs *r*, Fig. 34 (*c*), along the back, 2 feet apart, in order to support them. The fascias are held in place by means of wrought-iron anchors *s*, *s*, to which they are bolted with hexagonal-headed bolts, which enable the erector to use a wrench in this close place.

The newels are cast with the upper part of each separate. A wrought-iron rod runs through the base and the shaft of the newel, the lower end passing through a plate in the base, and the upper end through a plate in the head of the shaft; the newel is thus held firmly together when the nut is screwed on. The caps of the newels are cast with a shoulder and are secured to the newel with countersunk screws. The lower rail of the balustrade is secured to the fascia with countersunk screws, and the upper rail in the same manner to the newel and wooden hand rail.

32. In Fig. 35 is shown one of the risers, which, except the top one, are all alike. The flange *v* in the section is cast on the lower edge and receives the marble or slate tread, and the nosing *w* is extended at the back to give a bearing for the tread. At *x* is a check in which the lug of the string fits. The upper riser of the flight differs from all the others, as it must be wide enough to form a fascia and finish under the stairs, as shown at *n* in Fig. 34 (*a*), and at the same time provide a stop for the plaster of the ceiling. The method of casting is not described, as it is perfectly plain work.

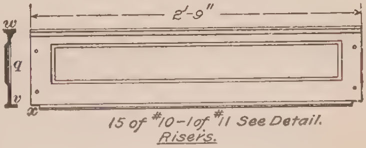
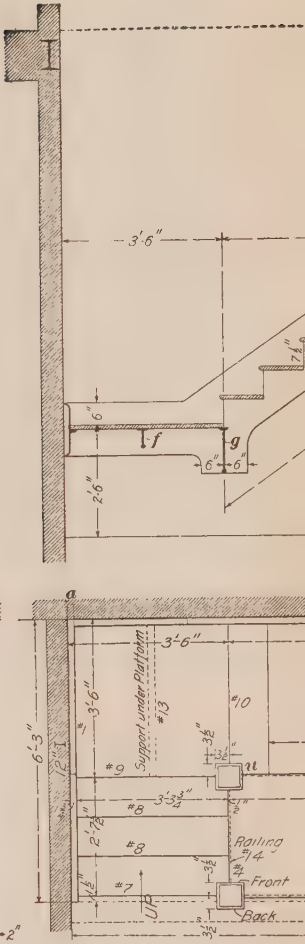


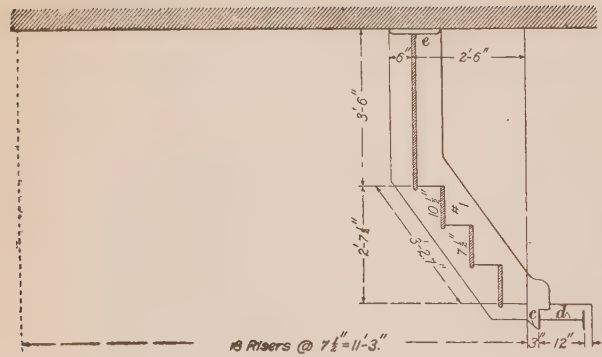
FIG. 35

PLATFORM STAIRS

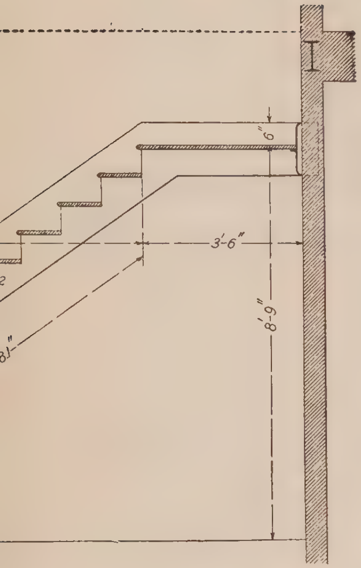
33. The stairs shown in Fig. 36 is one of a series of flights that may be used from the basement to the top floor of a building wherein the stairs just described would be suitable in the basement. This flight represents the run between the third and fourth floors of a building, and is typical of the whole stair system, which is enclosed on one side by a brick wall and on two sides with fire-block partitions. In many respects, the general construction is the same as in the previous example. The course to be pursued in laying out the stairs is the same as described for the previous case. The principal data to fix are: (1) the size of the well; (2) the height of the story; (3) the number of risers and treads, with their height and width; and (4) the width of the stairs. The drawing is then laid out precisely as in the preceding case, except that the parts in this example are numbered in the order they will be required, as is usually done with working drawings, in order to facilitate the process of erection. These numbers are marked on the plans, when laying out the stairs; and the workman, by referring to the plan, finds, for instance, that *#1* indicates the wall string, which must be first put in place. He consequently first looks for *#1*, and refers to each piece by its number instead of its name.

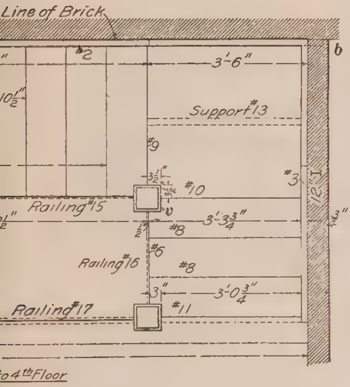
34. The holes indicated by the letters *a* and *b* in the plan, Fig. 36 (*a*), for the reception of the ends of wall strings, are 4 inches deep and contain either an iron or a stone templet for the strings to bear on. The wall string marked *#1* in the elevation (*b*) has a lug cast on the lower end *c*, through which it is bolted to the top of the beam *d*. At its upper end a lug *e*, which is shown in detail in Fig. 37 (*d*), is cast to receive the end of the string *#2*, which supports the platform and the stairs on the wall side of the second run. String *#2*, shown in Fig. 36 (*c*), has two lugs at *f* and *g* cast on the lower end—at *f* to receive the light beam that carries the platform, and at *g* to receive the end of the


3'-6"
7½"
6"
f
g
6"
6"
2'-6"
a
3'-6"
Support under Platform
#13
#10
6'-3"
3'-6"
12"
#1
3½"
1½"
u
#9
3'-3¾"
½"
#8
2'-7½"
#8
Railing
#14
#4
3½"
Front
1½"
#7
UP
Back
3½"

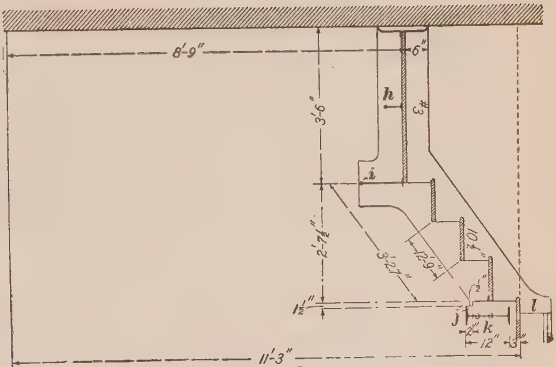

e
6"
2'-6"
3'-6"
10½"
#1
7½"
2'-7½"
3'-2½"
c
d
18 Risers @ 7½"=11'-3."
3"
12"
2"

(b)





o 4th Floor



18 Risers @ 7½" = 11'-3."

(d)

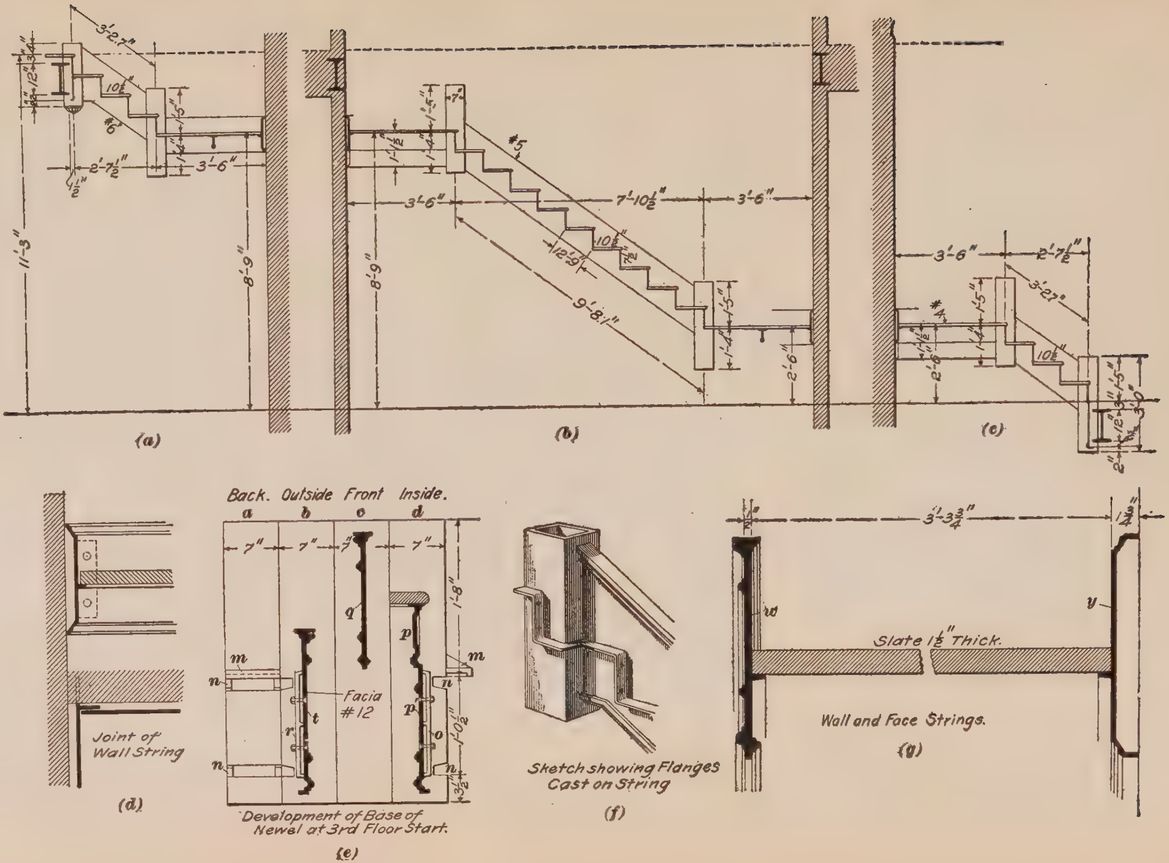

3'-2.7"
3/4"
12"
10½"
#6
1'-5"
1'-4"
2'-7½"
3'-6"
½"
11'-3"
8'-9"
(a)
1'-5"
7"
1'-4"
1'-1½"
#5
3'-6"
7'-10½"
3'-6"
10½"
7½"
12'-9"
9'-8.1"
1'-5"
1'-4"
8'-9"
2'-6"
(b)
3'-6"
2'-7½"
#4
1'-5"
3'-2.7"
1'-1½"
1'-4"
10½"
2'-6"
1'-5"
12"
3'-0"
2"
(c)
Joint of Wall String
(d)
Back. Outside Front Inside.
a b c d
7" 7" 7" 7"
1'-8"
m
n
q
p
Facia #12
t
r
p
o
1'-0½"
3½"
Development of Base of Newel at 3rd Floor Start.
(e)
Sketch showing Flanges Cast on String
(f)
3'-3¾"
1¾"
w
y
Slate 1½" Thick.
Wall and Face Strings.
(g)

FIG. 37

face string marked *#4* on the plan. The upper end of string *#2* has a lug, the same as that on *#1* at *e*, cast on it to receive the wall string *#3*. String *#3*, as shown in Fig. 36 (*d*), also has on the lower part two lugs at *h* and *i*—at *h* to take a light beam to support the platform, and at *i* to receive the face string *#5*. On the upper part of *#3* is cast a flange at *j*, through which it is bolted to the beam *k*; there is also a small extension, or easement, *l* cast on this string to receive the base finish in the hallways. Provision for allowance or variation has been made at the floor ends of the strings *#1* and *#3*, as indicated.

35. The face string *#4*, as shown in Fig. 37 (*c*), is cast with the first two newel bases attached to it, the lower one of which has a lug cast on the back, as shown at *m*, Fig. 37 (*e*), which is a detail of the development of the base, through which it is bolted to the beam. This detail shows the base of the start newel developed flat so as to disclose all four sides. The back *a* is checked out at *n*, so that it may fit over the flange of the beam. The inside face of the newel *d*, against which the first riser must fit, has a lug *o*. The riser *p*, which also extends to form the fascia *p'*, is bolted with countersunk screw bolts to the lug *o*. The front face of the newel *c* shows the section of the face string *#4* at *q*, and the outside of the newel *b* has a lug *r* to which the well fascia *t* is bolted. The second newel base on string *#4* has a lug shown at *u*, Fig. 36 (*a*), cast on the outside to receive the end of the face string *#5*. The end of string *#4* is bolted to the lug *g* on wall string *#2* [see Fig. 36 (*c*)]. The face string *#5* has the third newel base cast with it, and extends through to the wall string *#3*, to which it is bolted. The lower end is bolted to the lug *u* on the second newel base. On the third newel is cast a lug *v*, to which face string *#6* is bolted at its lower end. Face string *#6* has the base of the fourth newel cast on it, and the lugs are practically the same as those shown in the detail.

The next pieces that demand attention are the risers. It will be noticed by referring to the plan, Fig. 36 (*a*), that there are five kinds of risers, and that each is indicated by a number commencing at seven and ending with eleven; these risers are the same as in the first example, and have been described, except those marked *# 9*, which have a lug cast on the back at the center to carry the outer end of the light beam *# 13*, which aids in the support of the platforms. The fascia *# 12*, a section of which is shown at *t* in Fig. 37 (*e*), has ribs cast 2 feet apart along the back to stiffen and support it, while clamps, which are bolted to the fascia with countersunk screw bolts, are hooked over the beam. A detail, Fig. 37 (*f*), shows a perspective view of the string and base of the newel, with the flanges to receive the treads and risers. In the detail shown in Fig. 37 (*g*), *w* and *y* are sections of the face and wall strings, showing the moldings of each, the position of the slate treads, and the flanges supporting them. The railings include *# 14*, *# 15*, *# 16*, and *# 17*, shown in Fig. 36 (*a*), and are the same as those shown in Figs. 33 and 34.

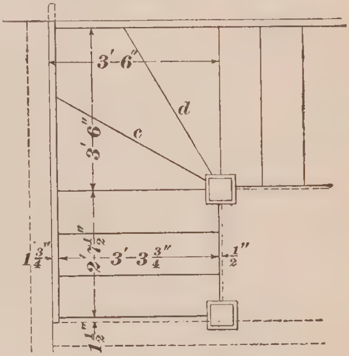


FIG. 38

It often happens that it is necessary to introduce winding treads in the angles instead of straight platforms. For example, had the distance between the partitions in Fig. 36 been but 11 feet 4½ inches instead of 14 feet 10½ inches, the treads might still have been kept 10½ inches in width by planning the corners as shown in Fig. 38. In this case, the strings would take a curve that would be determined by the

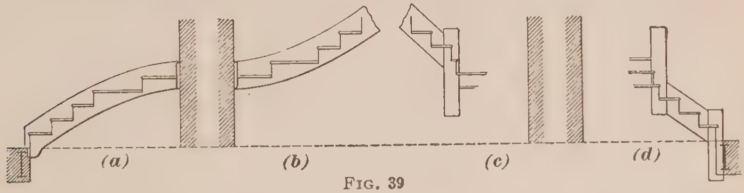


FIG. 39

intersection of the treads and risers with the wall string. The elevation of these curves is shown in the section in Fig. 39 (*a*) and (*b*). The only other detail affected by the difference of conditions would be the increased length of the newels brought about by the winder risers *c* and *d*, Fig. 38, having their start at the newel, thereby lengthening it by their height, as shown in the section in Fig. 39 (*c*) and (*d*).

SEMICIRCULAR STAIRS

36. In Fig. 40 (*a*) is shown the plan of a semicircular stairway; at (*b*), the development of the wall string; and at (*c*), the section through the strings; while in Fig. 41 (*a*) is shown the front elevation; at (*b*) the development of the face string; and at (*c*), a detail of the rail on the upper landing. The first three treads *a*, *b*, and *c* of the plan, Fig. 40 (*a*), are 11 inches wide, and the remaining ones are so spaced as to be wider than this, if measured on a line midway between the strings. The diameter of the well is 14 feet 6 inches; and, deducting twice the distance from the wall to the center of the treads, it will be found that the diameter of a circle drawn through the center of the flight is 9 feet $11\frac{1}{8}$ inches, or 119 inches, which, multiplied by 3.1416, will give for the circumference 373.85 inches. Dividing this by 2 and deducting from the result 1 inch (the distance from the top riser to the beam *d*) gives the length of the center line required as 185.92 inches. This divided by the number of treads determines the width of each tread on that line to be $11\frac{5}{8}$ inches. The lengths of the strings around the outer and inner circumferences are taken on the inside faces, and are determined in the same manner. In a stair of this character, it is not possible to make sections through any particular part in such a way as to be of any service, but the development of each string is given instead.

37. To lay out a plan of a flight of stairs of this kind, begin with the wall string and lay off from the foot of the flight the first three treads 11 inches wide, and the other

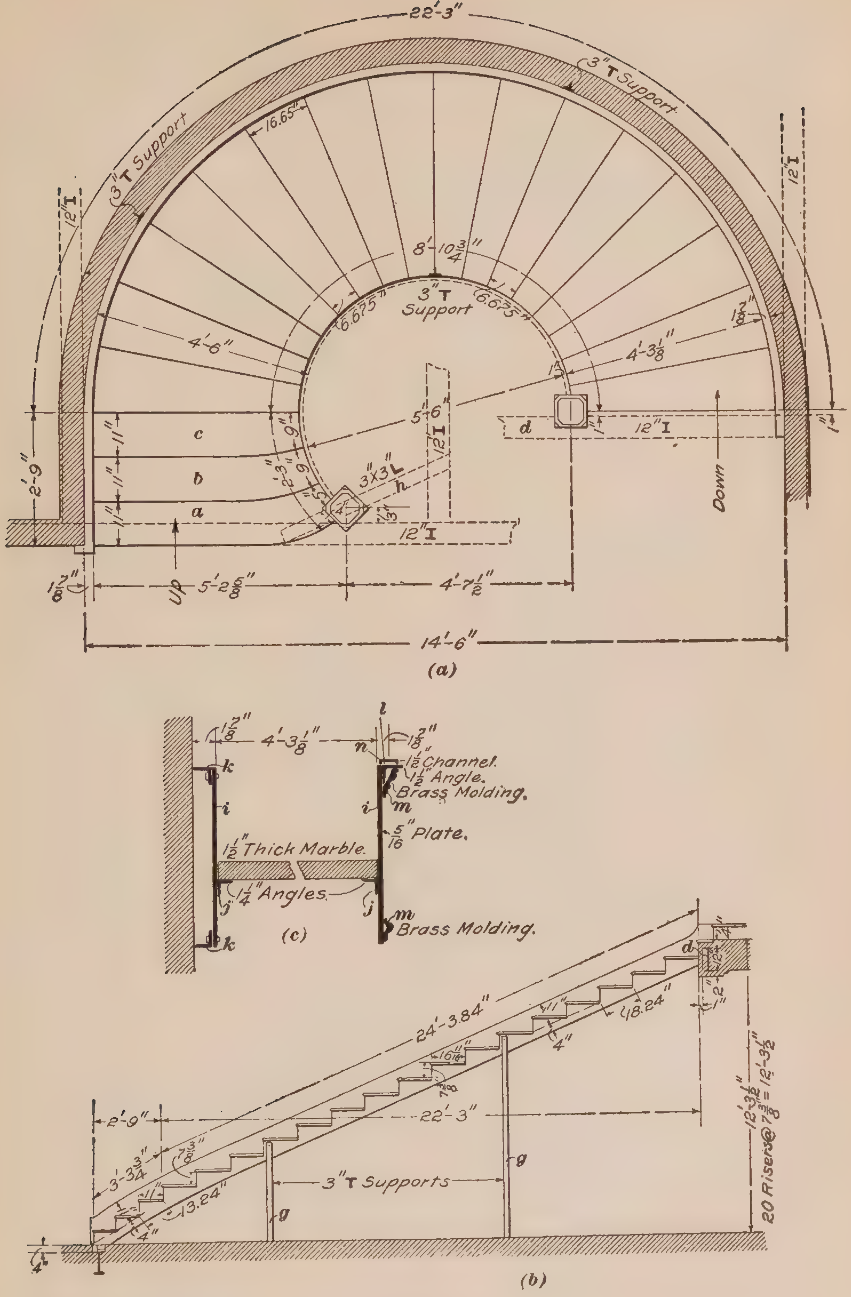

22'-3"
3" T Support
3" T Support
16.65"
12" I
12" I
8'-10 3/4"
3" T Support
6.675"
6.675"
4'-6"
4'-3 1/8"
1 7/8"
5'-6"
12" I
12" I
d
c
b
a
11"
11"
11"
2'-9"
9"
2'-3"
9"
3"x3" L
h
3"
12" I
Down
Up
1 7/8"
5'-2 5/8"
4'-7 1/2"
14'-6"
1"
(a)
1 7/8"
4'-3 1/8"
1 7/8"
l
n
k
1 1/2" Channel.
1 1/2" Angle.
Brass Molding.
i
i
m
5/16" Plate.
1 1/2" Thick Marble.
1 1/4" Angles.
j
j
m
Brass Molding.
k
(c)
24'-3.84"
d
4"
12"
2"
1"
11"
48.24"
4"
16 11/16"
7 3/8
2'-9"
22'-3"
12'-3 1/2"
20 Risers @ 7 3/8 = 12'-3 1/2"
3'-3 3/4"
7 3/8"
11"
13.24"
4"
g
3" T Supports
g
4"
(b)

FIG 40

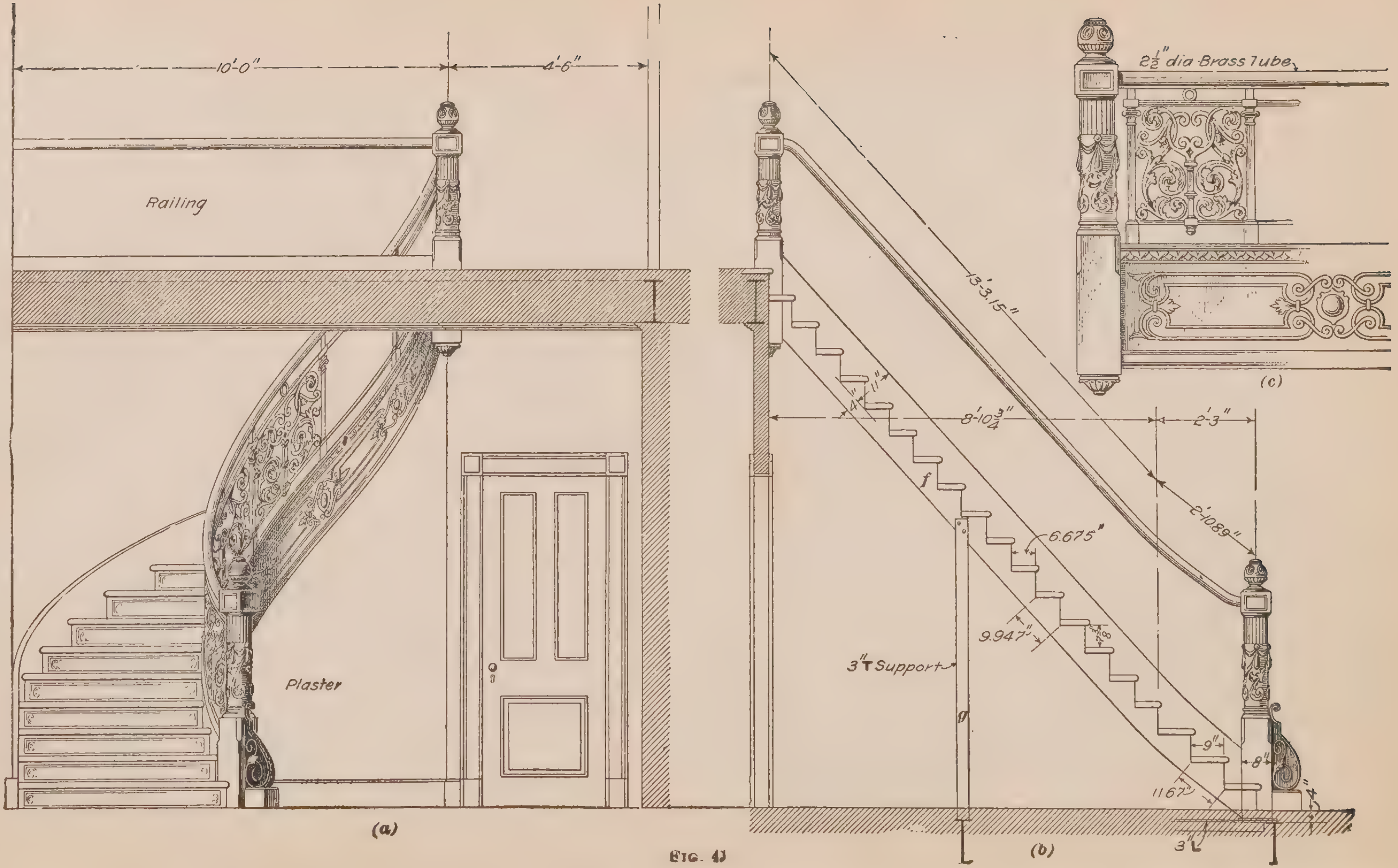

10'-0"
4'-6"
Railing
Plaster
(a)
13'-3.15"
8'-10$\frac{3}{4}$"
2'-3"
2'-10.89"
4"
11"
f
6.675"
9.947"
8"
3"T Support
g
9"
8"
11.67"
4"
3"L
(b)
2$\frac{1}{2}$" dia Brass Tube
(c)

FIG. 43

sixteen will be 1 foot 4$\frac{11}{16}$ inches, the latter dimension being found in the same manner as the width on the center line and used in the development of the string, as shown at (*b*). A line drawn through the lower intersections of the treads and risers will form a basis from which to determine the width of the wall string and to lay off the top and bottom lines of this string, as shown in Fig. 40 (*b*). The proportion of the treads to the risers in the short straight part of the string is 11 to 7$\frac{3}{8}$, while that of the curved portion is 16$\frac{11}{16}$ to 7$\frac{3}{8}$, thus causing the string to take a different angle; the juncture of these two parts should be eased off instead of showing the sharp angle, which would be out of harmony with circular stairs. This applies only to the wall string, as in the development of the face string, shown at *f* in Fig. 41 (*b*), there is a surface that is curved throughout its entire length. These curved strings are usually made of wrought-iron or steel plate that is capable of being bent to the required curve, and this bending is done by hammering on a curved block if the material is light, or by mechanical pressure in case of heavy work.

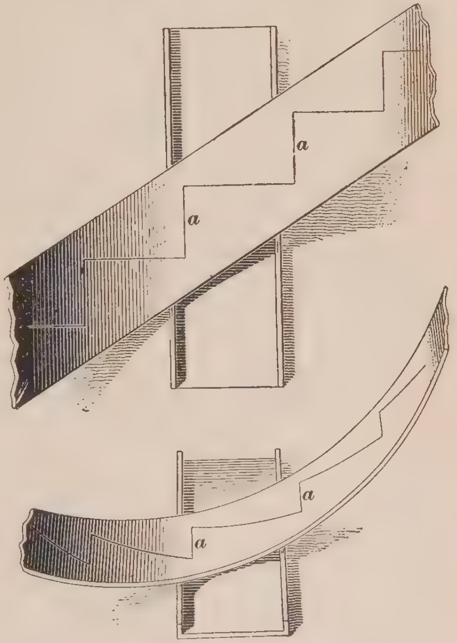


FIG. 42

38. With the exception of the straight part at the bottom of the wall string, both strings are helical in shape; that is, they take the form of a ribbon spirally wound around a cylinder and rising at a certain ratio.

To get this helical shape, the strings are first laid out flat, as shown in the developments, Figs. 40 (*b*) and 41 (*b*), with the lines of the treads and risers drawn on them; they are then laid across a block with the lines of the risers *a*, Fig. 42, parallel to the sides of the block, and while in this position are hammered or subjected to pressure every few inches. A wooden templet with one edge curved to the radius to which the string is to be bent is used to test the string and determine when it has been pressed to the proper curve. This templet is placed against the iron at short intervals, and held in a direction parallel to the lines of the treads. This bending may also be accomplished by passing the string in an angular direction through a set of rollers, provided they are long enough; this method, however, is seldom used, owing to the great length of roller required.

39. In making the pattern for the railing, it is advisable to first prepare a wooden drum of the same diameter as the stair well, on which the steps are laid out; and from them the top line of the string is obtained, which is also the bottom line of the railing. The top and any intermediate lines of the railing are then found by measuring perpendicularly from any point on the string line or from the center of each tread; and the whole railing may be either modeled directly to the proper curve or made straight and bent to the curve afterwards. The well holes of all stairs are framed before the stairs are built, and in straight stairs there is little more required in the shape of structural support; in curved stairs, however, it is often necessary to introduce special supports, as has been done in this case by the upright **T** irons *g* shown in Figs. 40 (*b*) and 41 (*b*). The circular partition under the string in this case is of terra-cotta blocks, and is therefore in itself incapable of affording sufficient support to the wall string. The strings should rest on the top of the floorbeams below, and should be bolted to the webs of the floorbeams above wherever possible; but, as this cannot always be done, diagonal bearings, such as shown at ***h***, Fig. 40 (*a*), should be provided between the nearest beams.

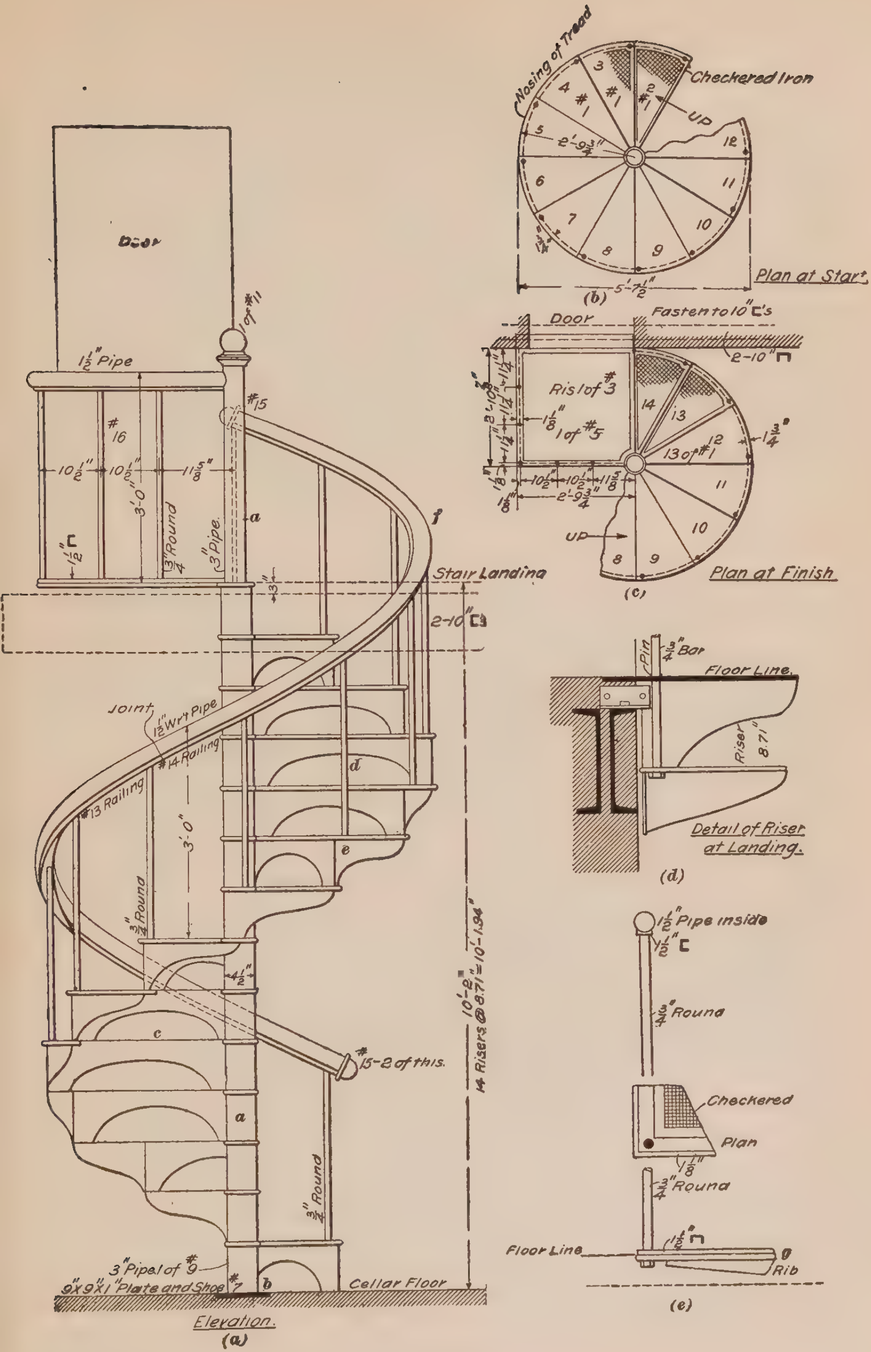

Nosing of Tread
Checkered Iron
UP
2'-9¾"
5'-7½"
(b)
Plan at Start
Door
Fasten to 10" ⊏'s
2-10" ⊓
Ris 1 of #3
1⅛" 1 of #5
13 of #1
1¾"
10½" 10½" 11⅝"
2'-9¾"
UP
(c)
Plan at Finish
Door
1½" Pipe
#16
10½" 10½" 11⅝"
3'-0"
¾" Round
3" Pipe
1½" ⊏
1 of #11
#15
a
f
Stair Landing
3"
2-10" ⊏'s
Joint
1½" Wr't Pipe
#14 Railing
#13 Railing
d
e
3'-0"
¾" Round
4½"
c
#15-2 of this.
a
¾" Round
14 Risers @ 8.71" = 10'-1.94"
10'-2"
3" Pipe 1 of #9
9"x9"x1" Plate and Shoe #7
b
Cellar Floor
Elevation.
(a)
Pin
¾" Bar
Floor Line.
Riser 8.71"
Detail of Riser at Landing.
(d)
1½" Pipe inside
½" ⊏
¾" Round
Checkered
Plan
⅛"
¾" Round
1½" ⊓
Floor Line
g
Rib
(e)

FIG. 43

40. The face string being of wrought iron, it must be bolted to the newel faces, and in view of this, flanges are cast on the newel bases for this purpose. The constructive details for these stairs in the connections, with the exception of the strings, are the same as in Fig. 36. These strings are shown at *i*, Fig. 40 (*c*); the treads are supported on wrought-iron angles *j* bolted to the string. The top and botton angles *k k* of the wall string and the top angle *l* of the face string are of angle irons riveted to the string. The upper and lower edges of the face string are finished with brass molding *m*, and the balustrade is first secured to the channel iron *n*, which in turn is bolted to the string.

CIRCULAR STAIRS

41. A type of circular stairway, similar to that described in *Architectural Drawing*, is shown in Fig. 43. This stairway is suitable in some such position as an engine room, from a sidewalk to a subcellar, or from an attic to a dome, or tower, or in any position where space is limited. The construction is of the simplest character, and consists of a central core or wrought-iron pipe *a* resting on a plate *b* at the bottom. The treads and risers *c* are of cast iron in one piece, with a collar to fit over the pipe *a*, so that in erecting the stair the risers and treads are slipped on as shown in Fig. 44. In order to keep them in place, the upright bars of the railing *d*, Fig. 43 (*a*), are continued down through each tread near the front edge to a lug, or projection, *e* on the back of the tread immediately

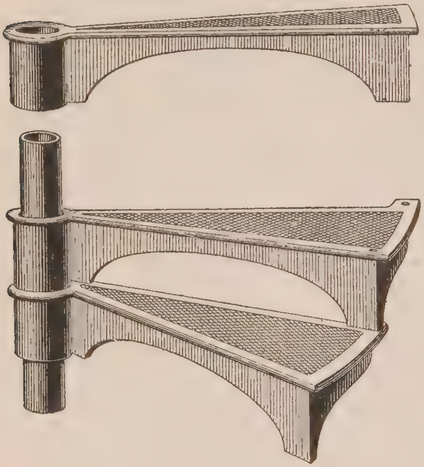


Fig. 44

underneath, and are secured with a nut. The top riser acts as a brace to hold the pipe in place, and is fastened to the beam with a wrought-iron strap of any suitable shape. There are no strings to be bent in these stairs, but the hand rail *f* must be bent to the proper curve. This rail is composed of a small channel iron with a $1\frac{1}{2}$-inch wrought-iron pipe on top.

42. To bend any bar or pipe, the most satisfactory results are obtained by using rollers, preferably run by power, as shown in Fig. 45, one of these rollers being capable of adjustment, so that the pipe or bar may be bent to any required radius. In this way, not only is it possible to give the hand rail the necessary curve, but, as the amount of rise per foot is known, it can be given this upward direction at the same time by setting the gauges, or guides, *a* and *b* to the proper angle. It is presumed that the stair is erected before the hand rail is bent; and to determine if the rail has been bent to the proper curve, it is laid over the top of the steps, and corrected by hand if necessary.

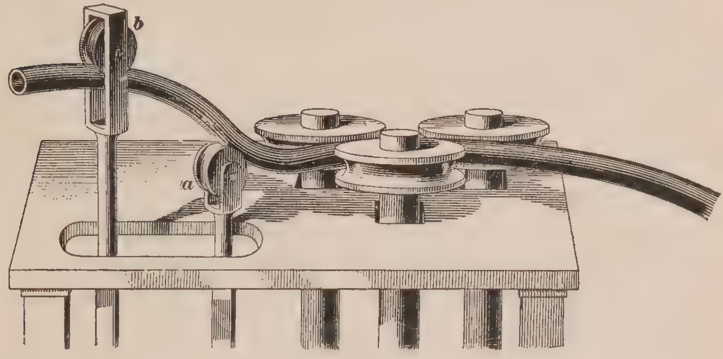


Fig. 45

It might, however, be required that the hand rail should be bent and set quite independently, and assuming that the rail were a flat bar, $1\frac{1}{2}$ in. × $\frac{3}{8}$ in., it would be accomplished as follows: An end view of a tread and riser would be laid out in outline, the sizes being taken at the center line of the railing, as shown in Fig. 46 at *b*. A part plan of the stairs, showing two treads, would then be drawn, as *ea* and *cf*, with a dotted line *c d* through the points *e*, *f* where the tread lines intersect the outline of the stair plan. Then, from *a* as a center, and with a radius equal to *b* (the true length of the rail over each step), arcs would be struck, intersecting the line *c d* at points *g* and *h*, which points are located on the true curve of the rail. A circle described through the points *g*, *a*, *h* would give the curve to which the hand rail should be bent. The bar is then bent to this new radius and twisted evenly along the whole length of the stairs in the manner and with the tools shown in Fig. 47. It will be found that the whole bar has now the form of a helix, and is of the required radius. Before being twisted, the positions of the balusters should be marked on the bar, and the holes for them bored or punched, as the case may be.

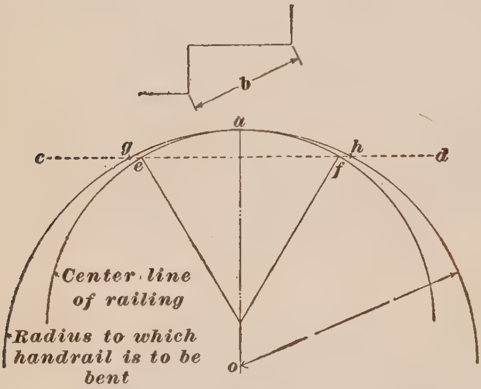


FIG. 46

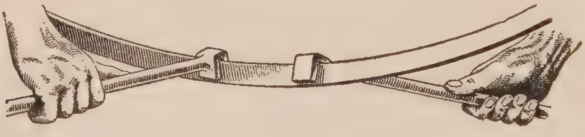


FIG. 47

43. In Fig. 43 (*b*) and (*c*), are two plans, one showing the start at the cellar-floor level and the other the finish of the stairs at the platform. The detail of the connection at the platform, the method of securing the baluster through the tread, and details showing the corner of the platform and the pipe forming the rail are shown at (*d*) and (*e*). The platform is strengthened by the ribs *g* cast on the under side, as shown at (*e*).

FRIEZES AND BALUSTRADES

44. Friezes.—In Fig. 48 is shown a cast-iron frieze. The ornament is bold, and has considerable relief, but being entirely on the surface and not undercut, it does not present any special difficulty in molding, and the model may be withdrawn from the sand without injuring the ornament. The modeling of this frieze should be in clay and then cast in plaster, and the working mold should be cast from this plaster model in the same material.

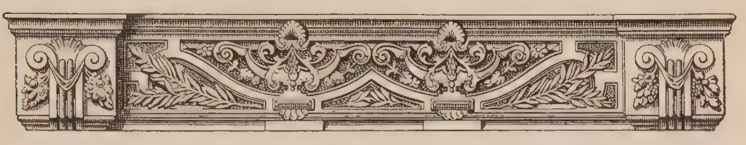


FIG. 48

45. Balustrades.—Figs. 49 and 50 are examples of stair balustrades or panels. Figs. 51 and 52 are examples suitable for exterior or exposed positions. The newel *a*, Fig. 49, is modeled, molded, cored, and cast in the same manner as the one already described. The balusters *b* are carved in wood and cast *solid*. They are secured with countersunk tap bolts at the bottom and top to an iron strap or rail *c* and *d* ¼ inch thick, and of a width equal to the baluster base, or to a channel iron.

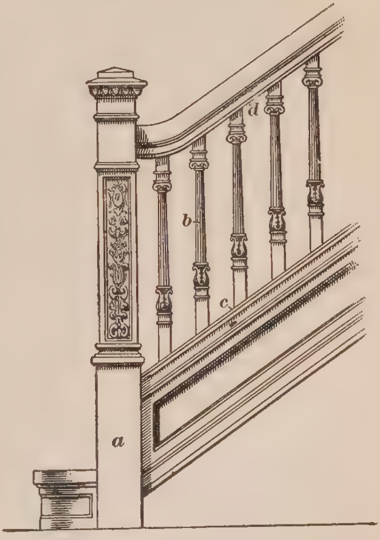


FIG. 49

The characteristic features of the design shown in Fig. 50 are the cartouch *a* at the center of the panel, the trident *b* that pierces it, the dolphins *c* that act as supporters, and the scrolls *d*, which complete a very rich and artistic panel. This design for a stair rail is especially good, as it fills the void between the string and the rail, affording perfect protection, while at the same time the design is not overloaded with ornament and is very well constructed.

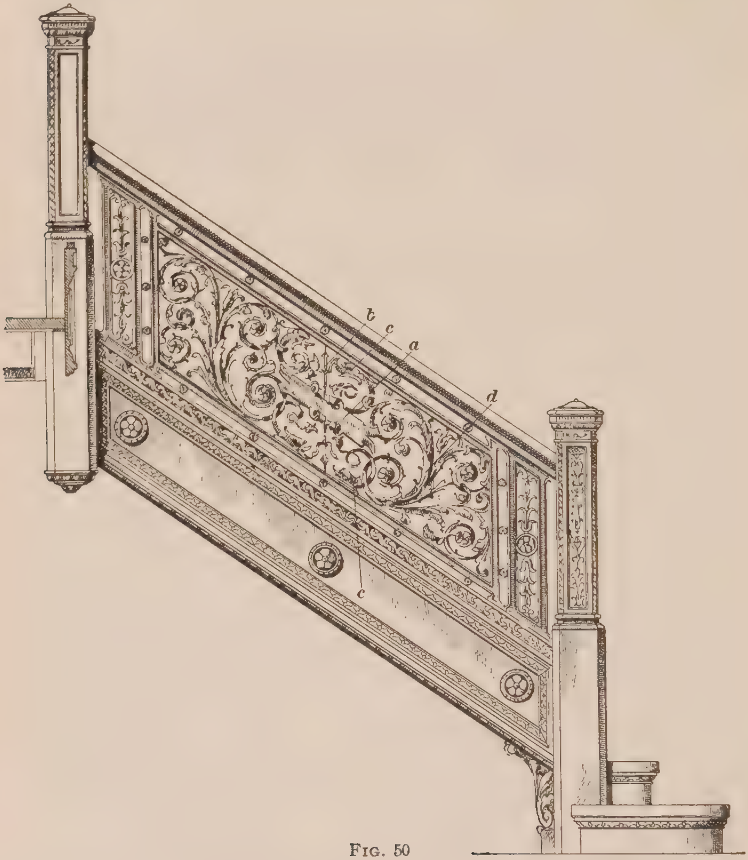


FIG. 50

The features of the railing shown in Fig. 51 are the long and the short panels forming its divisions. The large panels are strengthened and braced vertically at the middle with a post *b* running from the top rail to the lower rail, and horizontally with the rails *c*, *d*, and *e*. The short panel *f* is

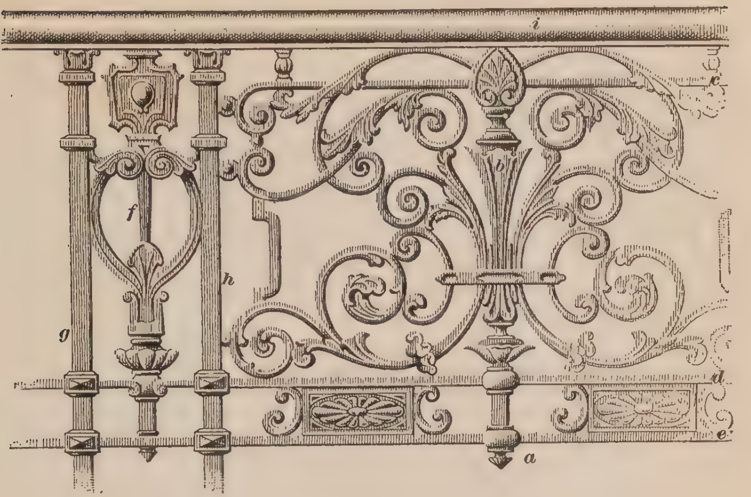


FIG. 51

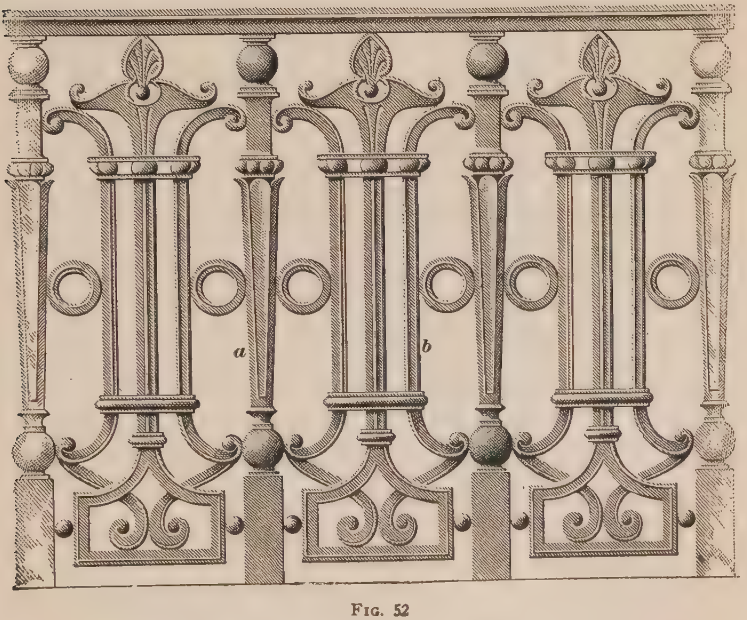


FIG. 52

let in between the posts *g* and *h*, combining them. The hand rail *i* is made of a brass or bronze pipe.

The rail shown in Fig. 52 is composed of a series of balusters *a* with panels *b* let in between them. The panel is well secured at four points on each side. The hand rail is formed of iron with a molded cap piece screwed on.

46. All of the foregoing stairs are such as might be used in ordinary office buildings or hotels, and having mastered the constructive details of these examples, it is possible to design any stairs, no matter how elaborate or massive. The character of the stairs should, of course, harmonize with the surroundings, and the principal flight, starting in the main hall, is often made a feature of the architecture by being of ample width and large proportions. The newels also can be treated in a special manner, and possibly the strings may be of wrought iron faced with ornamental cast iron. If the stairs are over 5 feet in width, it is necessary to introduce intermediate strings or supports to carry the load. Fig. 53 shows a florid design for a starting newel, which might properly be used for an important stairway.

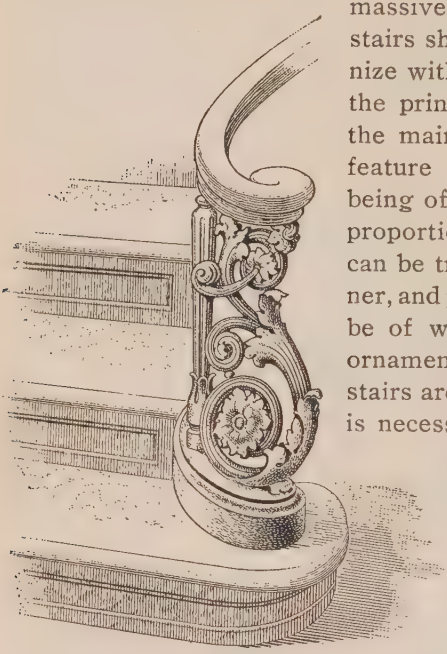


FIG. 53

Fig. 54 is reproduced from a photograph of a staircase with adjoining elevator enclosures. This is a good example of the style of stairs used in a typical office building. The effect of the decoration on the newels and strings and the repeating of the baluster panels of the stair railing are particularly good.

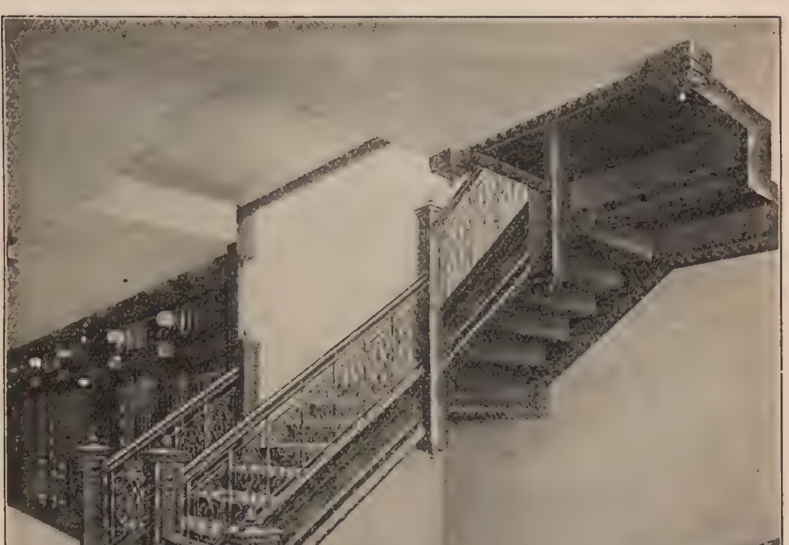


FIG. 54

BRONZE WORK

INTRODUCTION

47. Bronze.—The material known as **bronze** differs from iron in being an alloy of copper, tin, and zinc. It is softer and richer in appearance, and possesses many qualities that make it one of the most valuable metals for certain purposes. As bronze does not rust like iron, it may be used in conjunction with fine stone or marble without any danger of causing discoloration. It is capable of being finished in many ways, and its appearance, instead of becoming impaired, improves with age. The process of casting bronze is very similar to the process of casting iron, except for statuary and work of a similar nature. Bronze, however, shrinks to a greater degree than iron, and for this reason greater allowance has to be made.

48. Finishing Bronze Casting.—The amount of time and skill that may be expended in finishing and chasing bronze is practically unlimited, but depends entirely on the article itself and on the position it is to occupy. A cornice or cartouch, say on the façade of a building at a considerable height above the ground should not be finished in the same manner as a counter screen for a bank, but, rather, it should be left somewhat rough, just as it comes from the sand, the effect being better. On the other hand, when a fine finish is desired, it is filed and rubbed with fine emery and chased until almost every part of the surface has been carefully treated, the difficulty often being to decide just at what point to stop. Many fine castings are robbed of all character by overdoing the finishing.

Bronze and iron can be worked in a somewhat similar manner, except that bronze does not act in quite the same

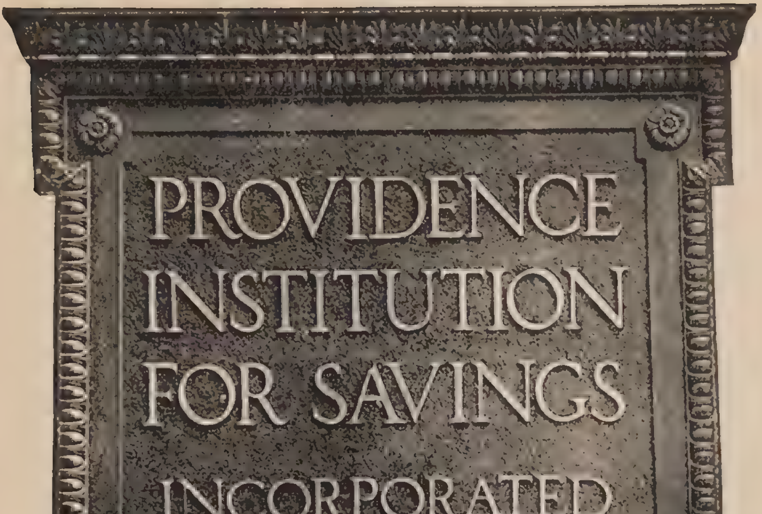

PROVIDENCE
INSTITUTION
FOR SAVINGS
INCORPORATED
•A•D•1819•
BANKING HOURS
•10•A•M•TO•2•P•M•
SATURDAYS
•10•A•M•TO•12•M•

Fig. 55

manner as iron when subjected to heat; it also presents difficulties that have to be overcome by repeated heating and careful working. Hammered work is done cold, the same as iron, but as bronze is softer and more ductile, it is easier to work.

EXAMPLES OF BRONZE WORK

49. Tablets and Cartouches.—Bronze is largely employed in the forms of moldings, capitals, and bases of columns, tablets, cartouches, etc. Fig. 55 is a design for a plain memorial tablet cast in one piece; or, if preferred, the letters may be made and applied separately. These tablets are usually fastened to brickwork or stonework by means of bronze expansion bolts with flat countersunk screw heads, which are tapped and covered with a rosette or button that screws into the hole in the bolt head.

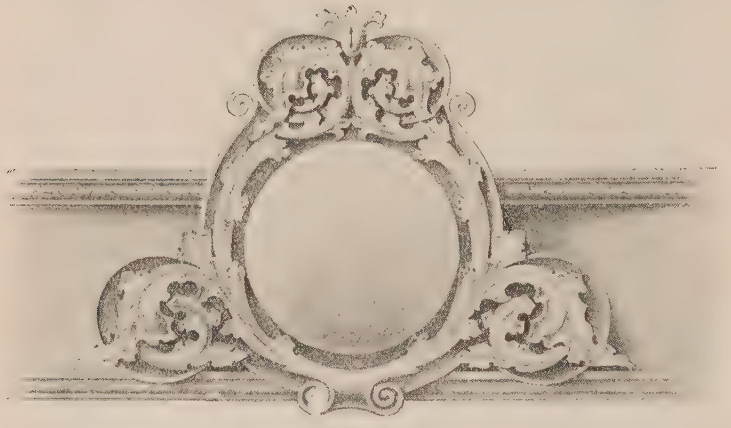


FIG. 56

Fig. 56 is a cartouch somewhat after the Italian Renaissance style, and marks the middle point of the frieze on which it is set. Possibly it might be placed over an entrance or on one of the stone piers of a building or any similar spot. The modeling may either be in very low relief or project boldly. If the latter, it is likely that the hollows would be undercut, and proper arrangements for this should be made in the pattern.

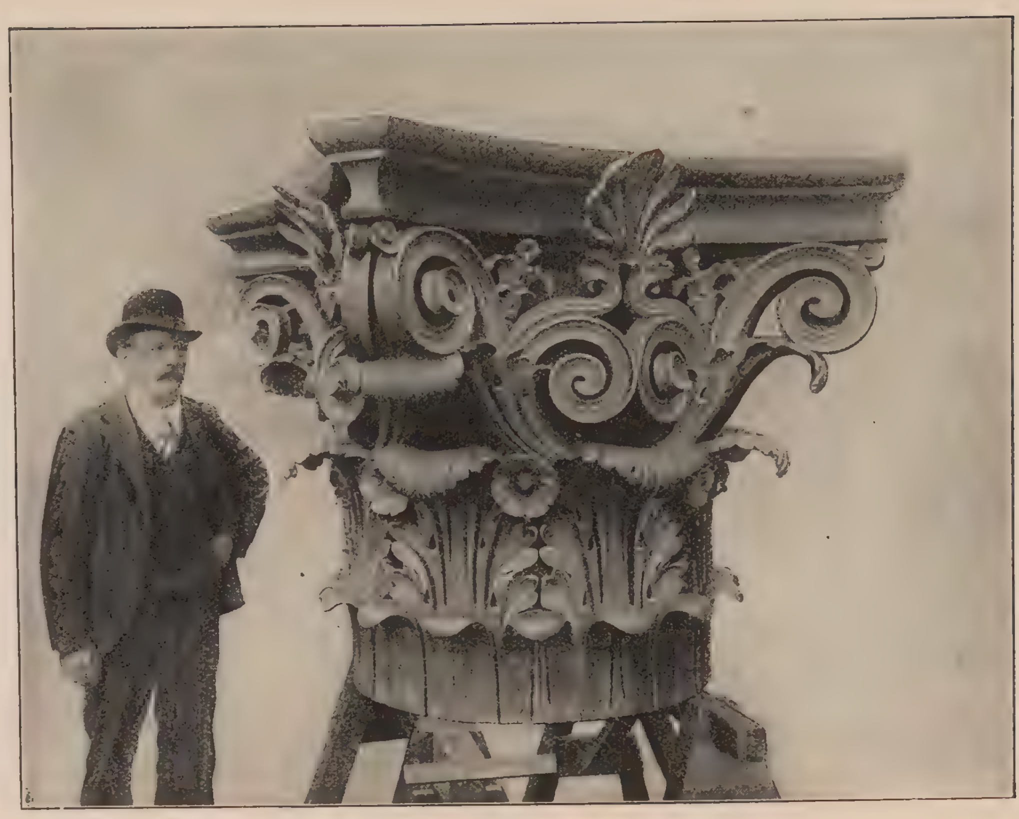


FIG. 57

50. Bronze Capital.—Fig. 57 represents a large Grecian Corinthian capital elaborately undercut, almost every separate member standing out free from the body. This body, or central part, is made separately as is also the abacus, and the individual scrolls and leaves are mounted on it one after the other. As a matter of fact, the whole capital could be cast in one piece if necessary or desirable, but would involve considerable expense and risk; therefore, the best plan would be to build it up in a number of units.

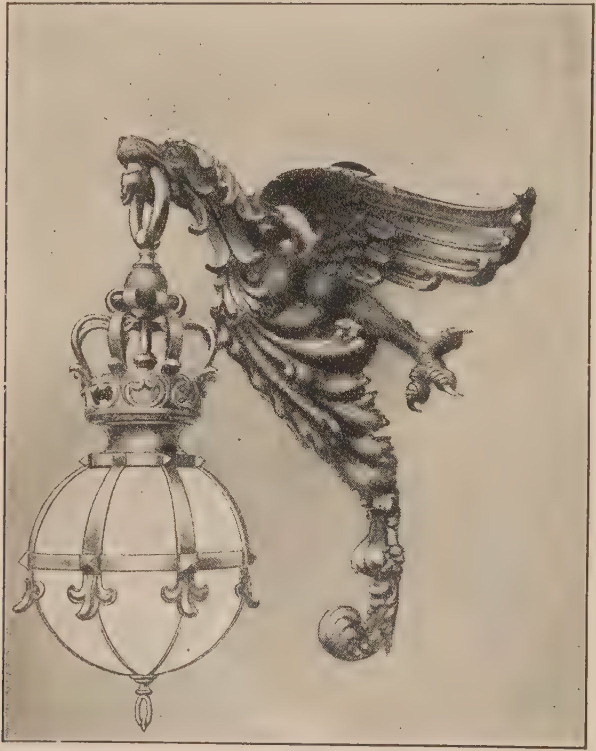


FIG. 58

51. Brackets and Lamps.—Bronze work as applied to lamps and brackets is susceptible of very beautiful treatment, of which Fig. 58 is a striking example. This figure illustrates one of a pair of lamp brackets in the form of a griffin

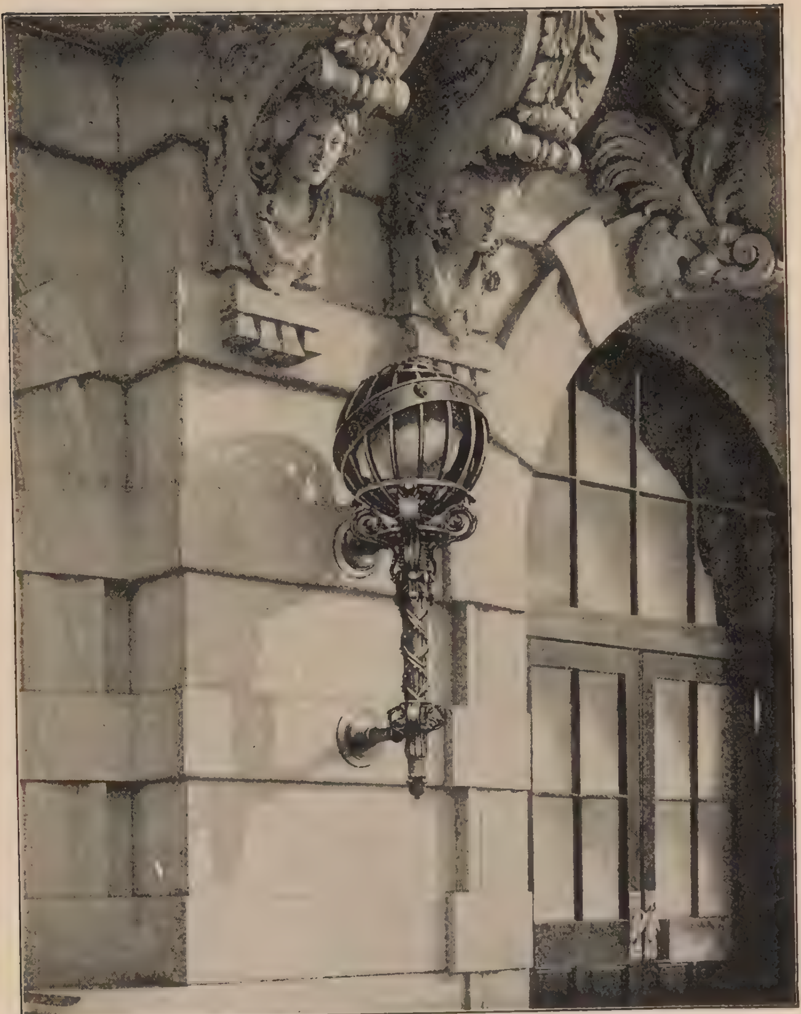


FIG. 59

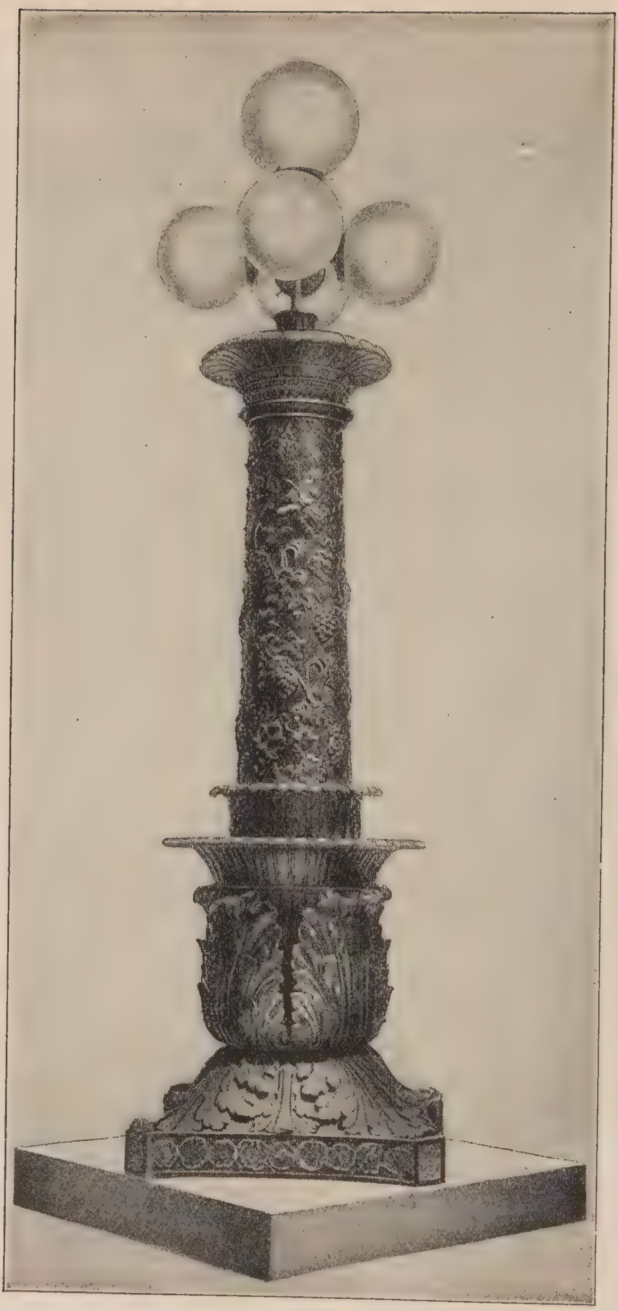


FIG. 60

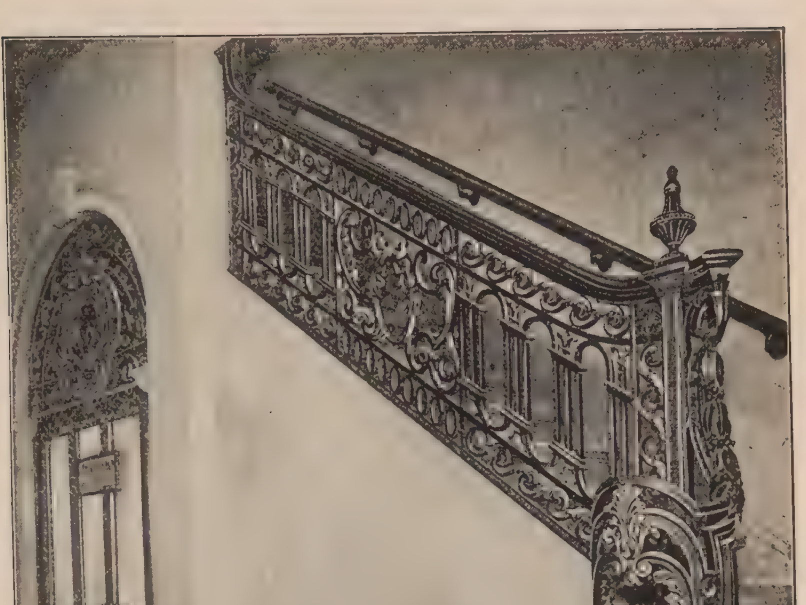


FIG. 61

with outstretched wings and bearing the globe depending from its jaws. The combination of utility and beauty are well worked out, in that the bands around the globe are kept entirely on the upper part so that the light is not obstructed in a downward direction, where it is most desirable. The whole pose of the body is strong, and the effect is brisk and lively.

Another beautiful design having the shape of a torch supported from the wall on two straight arms is shown in Fig. 59. This design is totally different from the preceding one, as it is almost purely decorative. The element of light is used only as part of the general scheme. The light is surrounded by a skeleton globe with an equatorial band on which are the signs of the zodiac. It was designed for the office building of the American Geographical Society.

52. Lamp Column.—In Fig. 60 is illustrated another type of lamp, being a standard or column rising from a base and resting on a stone block. The modeling of the acanthus leaves and the trailing vine is exceptionally good, as are also the general proportions.

53. Newels.—Fig. 61 shows the starting newel and part of the railing for a marble stairway suitable for a bank or private residence. The effect of the curved newel with the trailing leafwork circling around on top of the marble base adds greatly to the appearance of the hall in which the stairway is placed.

A similar effect is shown in Fig. 62. The design in this case is marked by great solidity and massiveness. The stair string here is also of bronze, although the weight of the stairs is borne by a steel beam or channel behind the bronze string, being concealed by the string and the marble work.

The character of the design in both examples is determined by the hall, which in the former case is comparatively small and dainty and in the latter, lofty and spacious.

54. Elevator Screens.—Fig. 63 shows a bronze elevator screen, the transom grille being designed to contain the dial indicator, which shows the movement of the elevator car as

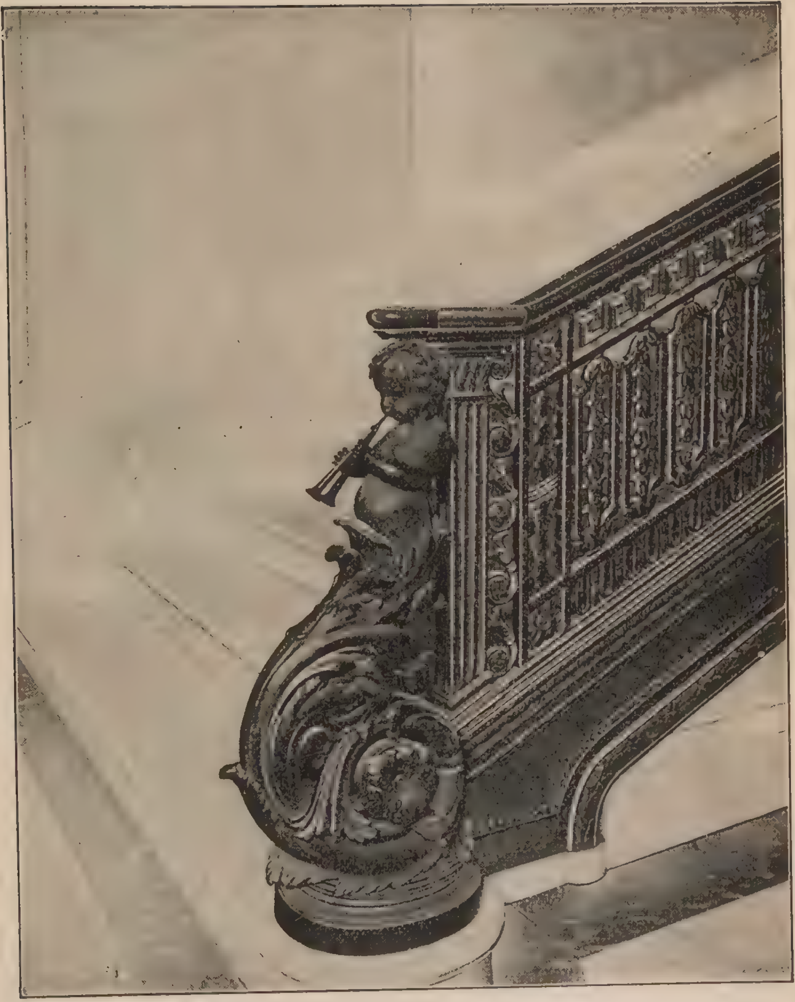


FIG. 62

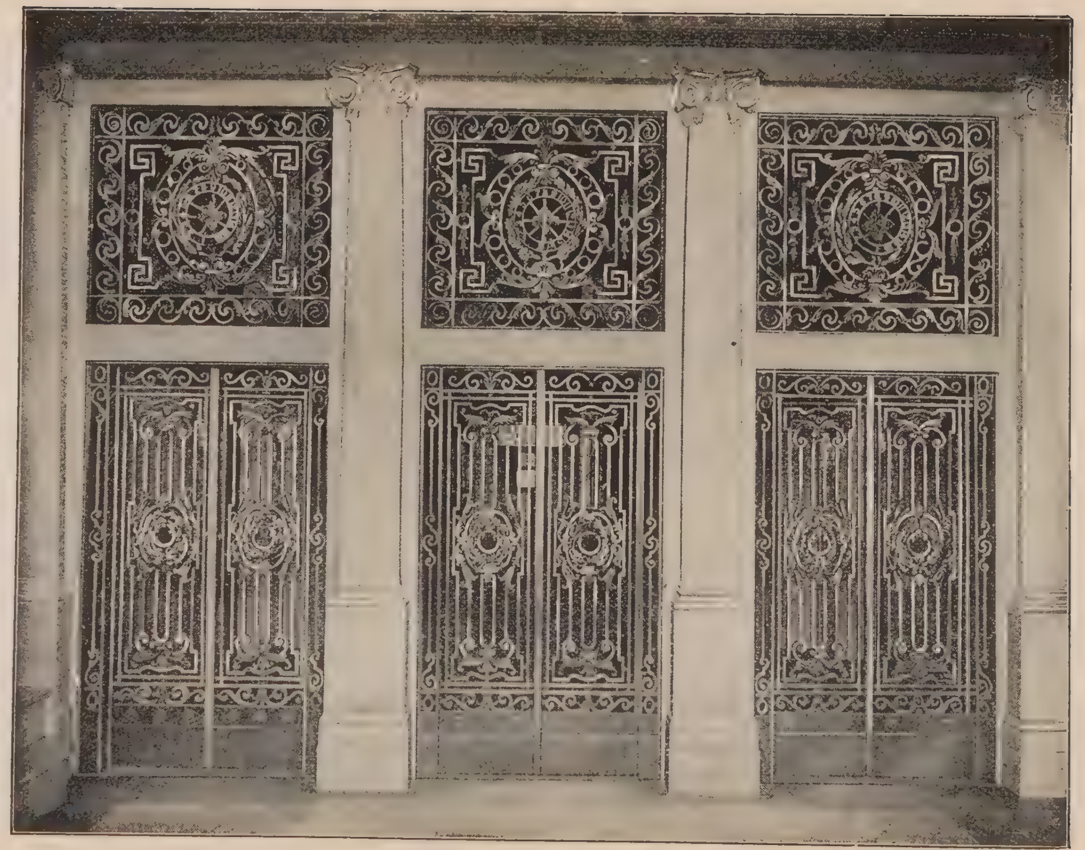


Fig. 63

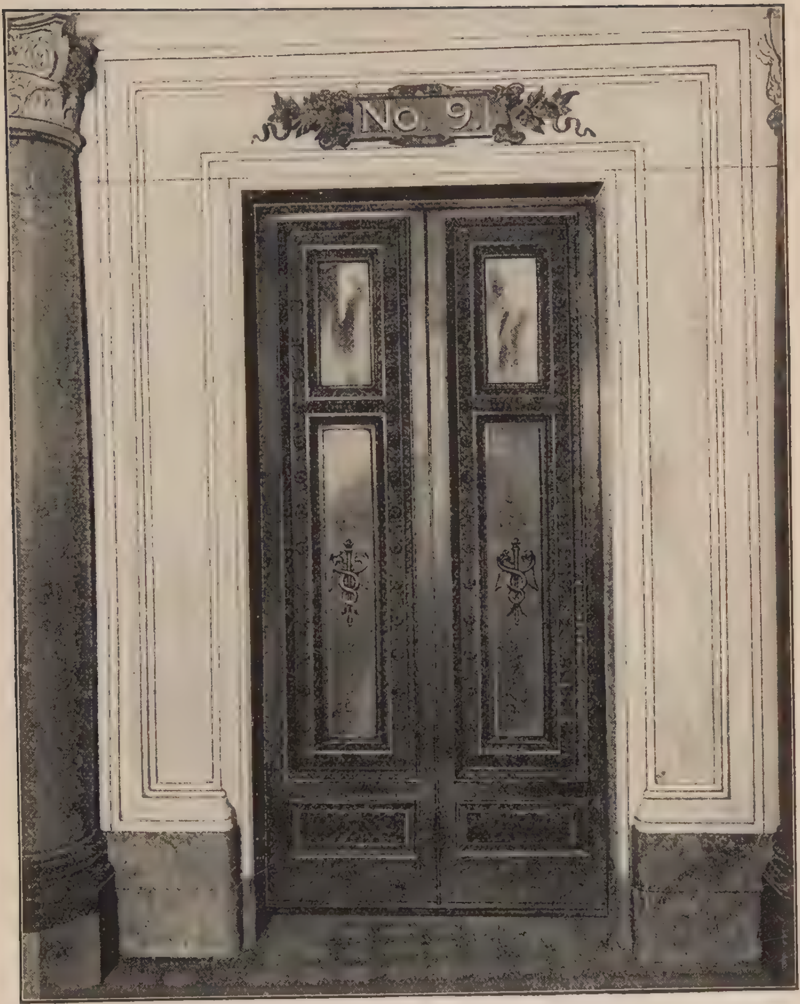


Fig. 64

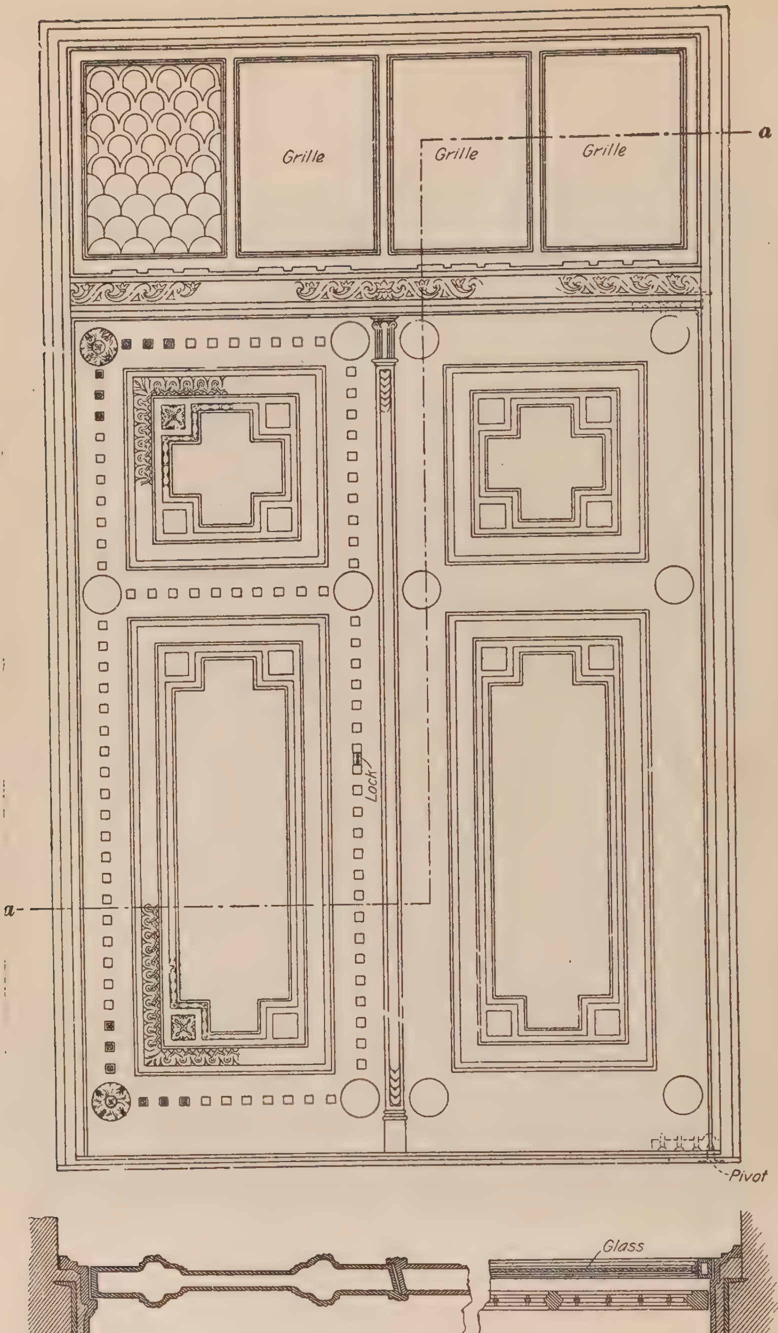


Fig. 65

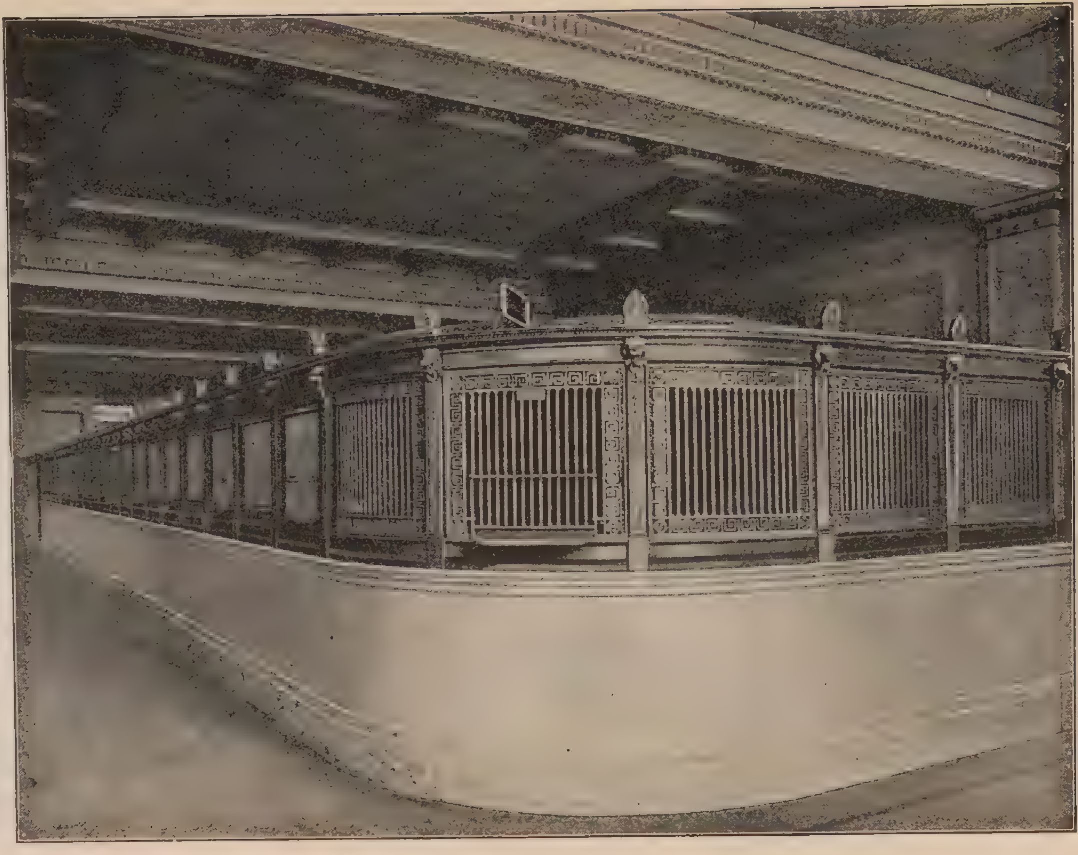


Fig. 66

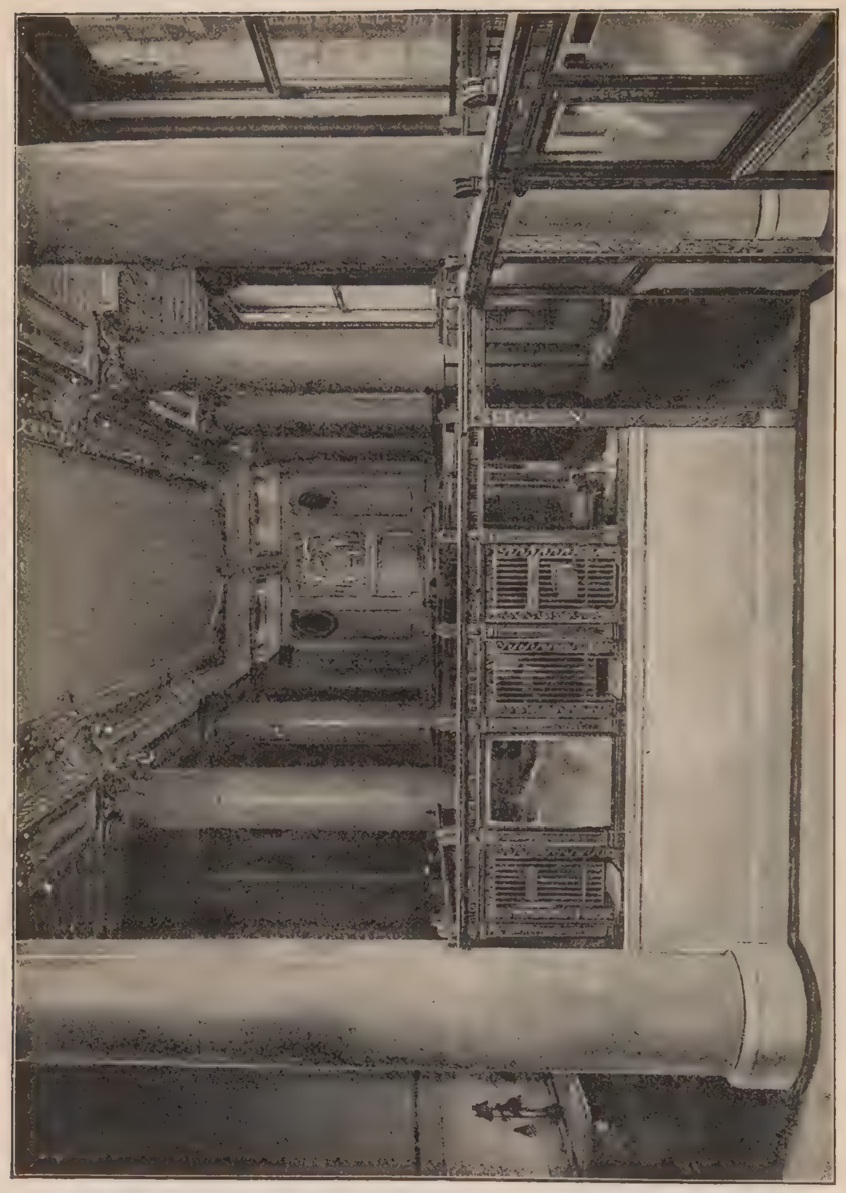


FIG. 67

it travels up or down. This design is for a combination of wrought and cast bronze, the straight bars being wrought and the scrolls and leafwork cast.

This screen could just as well be made of either all wrought or all cast bronze. If of the latter, however, the work of filing and finishing the straight bars would be greater, and the result would not be so satisfactory. As to which parts of any design shall be cast and which wrought, is to a great extent a matter of expediency, the artisan using his own judgment as to what is most convenient.

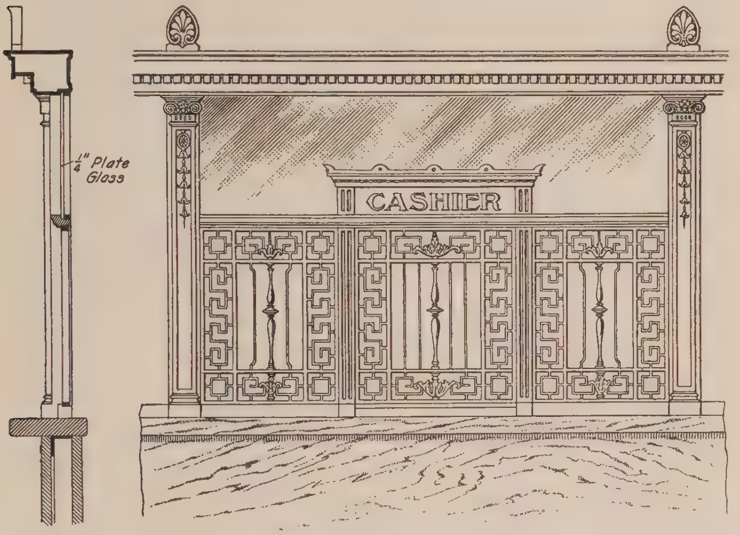


FIG. 68

55. Doors.—Entrance doors are made of bronze in many designs, depending on the style of the building in which they are to be used. Some are in grille form with glass panels, and others are solid, like Fig. 64, with the upper panels glazed. They may be cast or built up out of sheet bronze planted on a wooden core or on an iron or bronze skeleton frame, in which case the moldings and ornaments are applied separately. The fitting and jointing should be carefully done, so that the work as a whole may look solid.

Fig. 65 shows a similar pair of doors, but with a transom light overhead, the glass being protected by a heavy grille. In order that the glass may be cleaned, it is set in a separate frame, which may be hinged at the top or bottom, or, if preferred, at the sides. This door is shown as a solid casting, but may be built up as before mentioned.

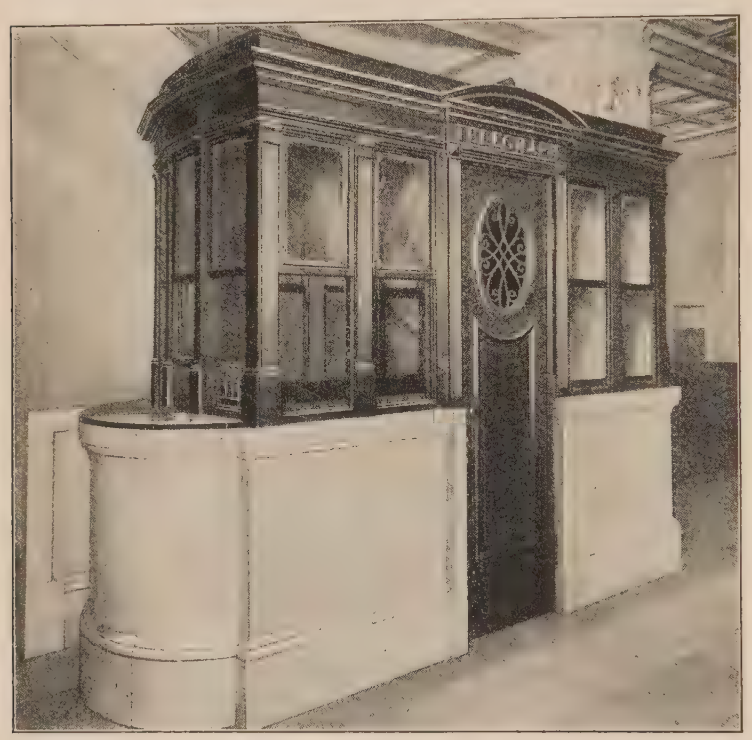


Fig. 69

56. Counter Screens.—Figs. 66 and 67 illustrate counter screens for banking rooms, and are designs of exceptional merit. These screens are made chiefly of cast bronze. In every case, the paneling is backed up with plate glass, which may be clear, frosted, or decorated in any manner desired. Fig. 68 shows another design in which the grille-work is lighter and is made of wrought bronze. The section shows how the whole screen is supported by a skeleton wrought-iron frame concealed by the marble panels of the wainscot. The bronze posts have a wrought-iron rod running through them and bolted to the angle framework, in order to insure rigidity. The wickets in front of the officers' desks are, of course, hinged so as to open.

57. Telegraph Booth.—Fig. 69 shows a complete telegraph booth constructed of bronze and marble. The construction is somewhat similar to that of the counter screen. As the marble, being in slabs about $\frac{7}{8}$ inch thick, has very little bearing strength, the weight has to be carried by some kind of framework, preferably wrought iron.

As has already been stated, almost any of the iron examples may be made in bronze, the chief difference in execution being the amount of time expended in finishing the work.

ORNAMENTAL METAL WORK

(PART 2)

WROUGHT-IRON WORK

METHODS OF MANUFACTURE

CHARACTERISTICS

1. Wrought iron and steel differ from cast iron principally in the characteristics that they are soft, malleable, and fibrous, while the latter is hard, brittle, and crystalline. This difference in character is due to the method of manufacture, as both kinds of material come originally from the same ore. Wrought iron and steel are purer than cast iron, as phosphorus and sulphur are eliminated as far as possible, as well as other ingredients that abound in cast iron. It is the carbon that gives cast iron its hardness, and the phosphorus that makes it brittle, while the elimination of the sulphur renders wrought iron malleable and capable of being forged. While it is practically impossible to entirely eliminate these ingredients in the manufacture of wrought iron, they may be so reduced as to be harmless. The presence of too much phosphorus will render the iron what is termed **cold short,** that is, brittle, or liable to split or break when hammered or bent cold. Sulphur, however, does not so much affect the cold working of the iron, but if present in excess, it tends to make it **hot short,** or brittle at a red heat, and unweldable at any temperature.

The value of these characteristics will be better appreciated when the methods of working are described.

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TOOLS AND IMPLEMENTS

2. In some structural work, cast iron is used extensively on account of its cheapness; but for certain classes of work, cast iron is not suitable, and wrought iron is employed almost exclusively.

Ornamental wrought-iron work may be divided into two general classes; namely, that which requires to be fashioned while hot, and lighter work, which is manufactured from cold materials. In each case, the original material is in the same form—long bars of varying widths and thicknesses, which are worked with vise and pliers, or forged with hammer and anvil, into any desired shape. The dominating feature of some designs is frequently the repetition of similar scrolls or rings; and when there are a number of these, it is necessary that they should be produced rapidly and exactly alike.

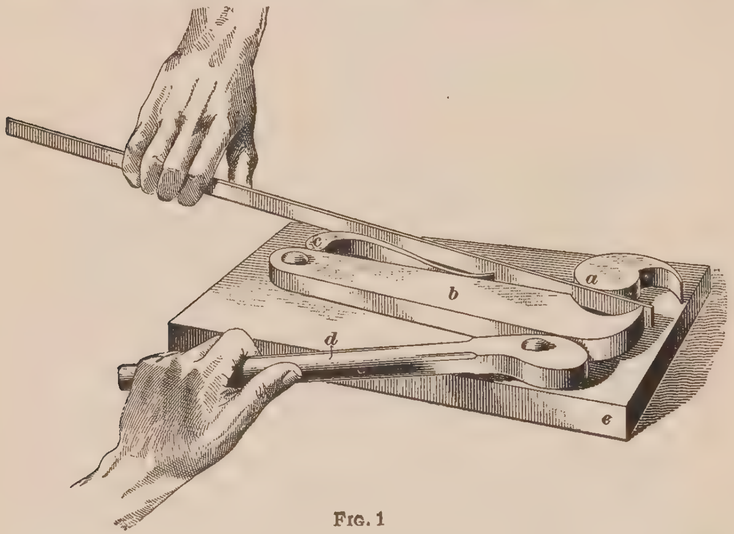


FIG. 1

In making any small scroll of light iron, the first and most important step is the forming of the small quirk, or curl, at the center; the method and machine for doing this is shown in Figs. 1 and 2. The tool employed is of a very simple character, and consists of a templet *a*; a clamp, or die, *b*, which is pivoted at one end, the other end fitting over the templet; a spring *c*, which keeps the die clear of the templet; and a lever *d*, which forces the die into place. In Fig. 1, the lever is thrown back to allow the clamp to be pressed open by the spring *c*. The bar, the end of which is to be bent, is introduced between the templet *a* and the clamp *b*. The lever is then pulled forwards, forcing the die against the templet, and the beginning of the scroll is formed. The bar is then brought around to the position shown in Fig. 2, and the first convolution of the spiral is completed.

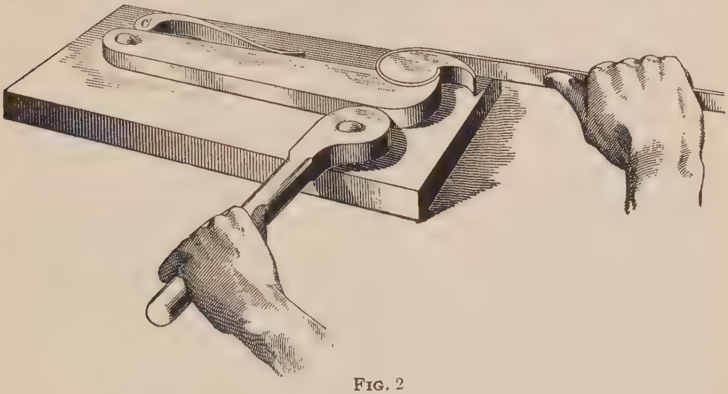


FIG. 2

3. The bar is now placed in the machine shown in Fig. 3, and the remainder of the scroll is formed. This machine consists of a shaft *a*, on which a screw thread is cut, and over which is coiled a steel spring *b*. On one end of the shaft is a crank, or handle, and on the other end the disk *e* carrying the coil, or volute, *f*, which forms the die, or pattern, for the rest of the scroll. This plate and volute are detachable, so that different sizes of scrolls may be formed on the same machine.

The bar, having had the first convolution of the scroll formed as already described, is now placed in the machine, as shown at *h*. The lever *g* is pressed against it to hold it in close contact with the volute *f*, and the disk is revolved until the scroll has assumed the proper number of convolutions.

As the shaft turns, the screw thread causes the disk to advance, and the bar *h* is coiled evenly in one plane, instead of conically, as might appear from the spiral on the disk. As the disk advances, the edge of the spiral in contact with the lever *g* is always in the same relative position. When the shaft has reached the point where the proper number of revolutions has been attained, a catch releases the nut from the screw thread, and the spring *b* throws the shaft and disk back to their original position, and releases the completed scroll, which is now cut off the bar, and another one prepared in the same manner.

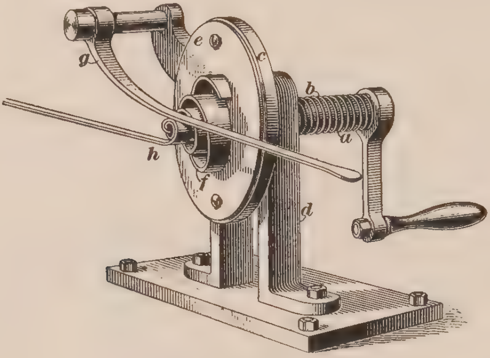


FIG. 3

With such appliances one man can make from 300 to 600 scrolls in a day, according to their size and weight; but where only a few scrolls are required, it is usual to make them almost entirely by hand, for which tools similar to

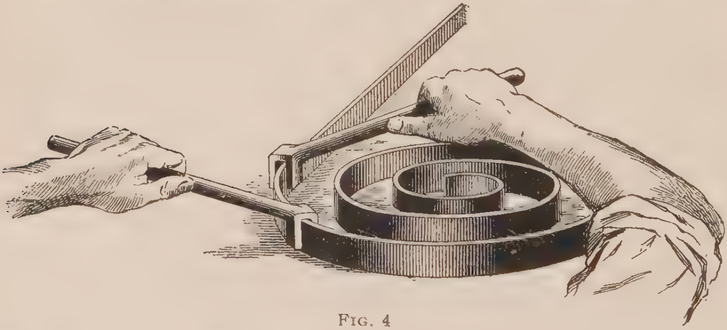


FIG. 4

those shown in Fig. 4 are used, the operation being so simple that description is not necessary.

4. As it is more economical to have special machines for the manufacture of scrolls in quantities, the same applies to the twisting of flat bars, and for this purpose the appliance shown in Fig. 5 (*a*) is used. This apparatus consists of a fixed upright *a*, with a socket to receive the pipe *b*, the other end of which rests in the movable upright *c*. The upright is arranged to travel along the bedplate by means of a threaded shaft *d*, so that the length of the pipe *b* may be changed to suit the length of the twist required to be produced. The bar to be twisted is passed through the pipe and the slot in the lever *e* until in proper position, after which the slotted piece *f* is dropped into the pocket, as shown in Fig. 5 (*b*). If the length of the pipe is such that the distance between the lever and the slotted piece is of the desired length for the twist, and the bar is then held at these two points and prevented from revolving independently, the lever can be wound around as many times as is necessary to produce the required twist. The greater the number of turns, the closer will be the twist. The piece *f* is made loose and dropped into place, so that it may be easily lifted out when the twist is completed, and thus allow the finished bar

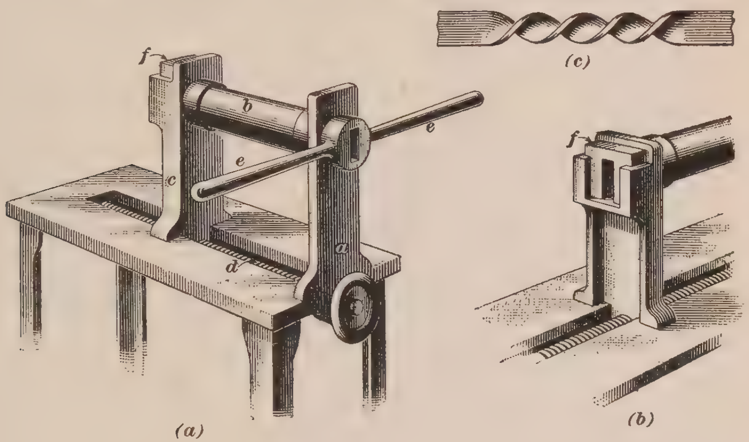


FIG. 5

to be withdrawn without twisting in through the slot, as would be necessary if the slots were permanently fixed in each end. The pipe *b* merely acts as a guide to prevent the bar from bending in a lateral direction when the twist is of considerable length.

5. The machine just described is for making a regular twist, as shown in Fig. 5 (*c*), but another form of twist in common use, especially in light grille-work, is made by giving the bar a series of half turns, as shown in Fig. 6.

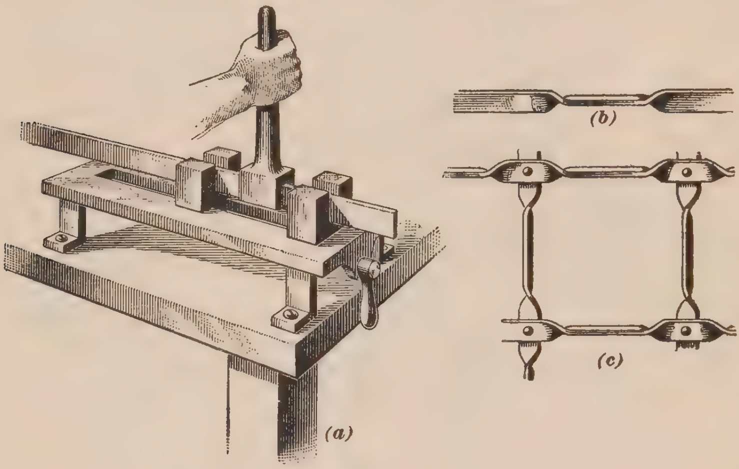


FIG. 6

The bar is dropped into two slots, as shown at (*a*), one of which can be adjusted by means of a long screw underneath the bedplate, so that the length of the part to be twisted may be regulated. It is then grasped between these slots by the loose clutch, and given a half turn, producing the result shown at (*b*). If the bar is to form a part of a square mesh grille, as shown at (*c*), there will be a number of these twists to each piece, and the distance from center to center should be marked out before the twisting is commenced. If the quantity required should be great, it might be advantageous to make a set of fixed pockets fixed to the proper centers, so that six or more turns could be made without lifting the bar.

The foregoing are a few of the tools used in the manufacture of light grille-work; where this class of work is produced to any great extent, however, there is a constant demand for new tools to meet the requirements of special conditions, but these tools cannot be bought and therefore must be made. It would be impossible to provide for the manifold variations that are likely to occur; but, apart from these special tools, those that are here illustrated are always in demand, and supplement the general machines, such as drills, punches, lathes, etc.

BAR ORNAMENTAL WORK

GRILLES

6. Simple Designs.—Having described the tools used in working wrought-iron bars into forms for grilles, a few examples of the simpler forms of grilles are shown in Figs. 7 to 10. These are plain basket patterns, and can be made from any size iron and set to any mesh. The frames are of angle iron, the ends of the meshwork being riveted to them. The meshwork grilles, being of an interlaced pattern, form a strong and economical screen to manufacture. If the surface to be screened by this basketwork is considerable, it is desirable to place rivets at intervals throughout the mesh; otherwise, the metal strips that form the mesh are likely to slip out of place and become distorted.

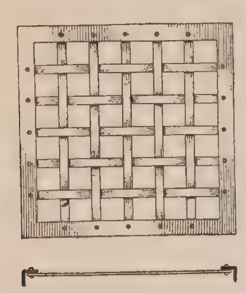


FIG. 7

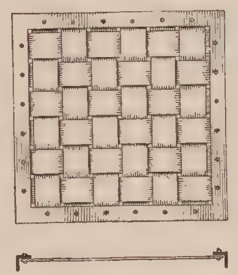


FIG. 8

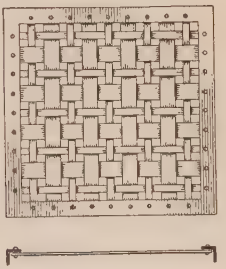


FIG. 9

If a more ornamental grille is wanted, the simplest variation is obtained by twisting the bars as shown in Fig. 11, the result being that a mesh is produced with the edges toward the eye and a series of flat crosses at the intersections. If a border to this grille is desired, the scroll ornament shown in Fig. 12 is suitable and inexpensive; a glance at the illustration will show that this scroll is made by simply turning the ends of each strip or bar. In this case, an angle-iron frame could not very well be used, because part of the scroll would be hidden by the flange of the angle. The frame may be a flat bar, though a small channel would be preferable, as the ends of the rivets that fasten the scrolls could be hidden in the hollow of the channel.

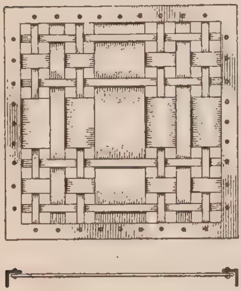


FIG. 10

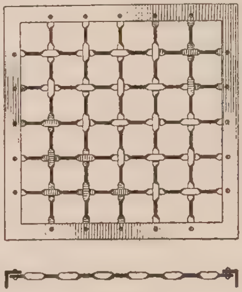


FIG. 11

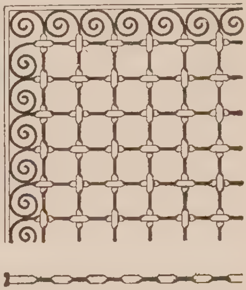


FIG. 12

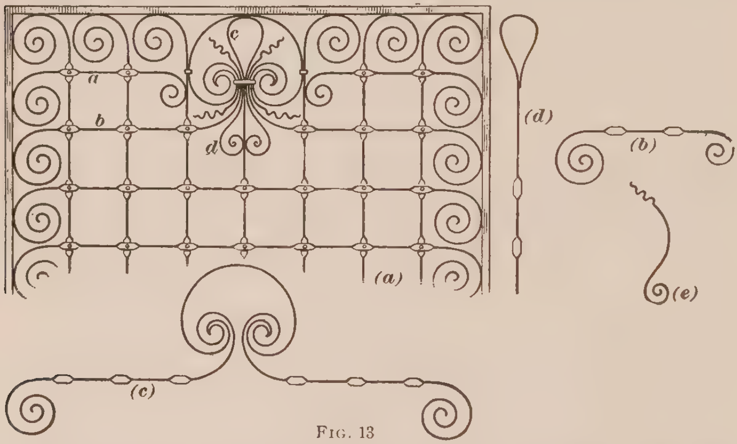


FIG. 13

7. A great variety of grille designs have the square meshwork shown in Fig. 11 as a basis, with additional ornament introduced at top and bottom, as shown in Fig. 13 (*a*), or with a border and center ornament, as in Fig. 14. It will be seen that the ornament is formed to a great extent by turning the ends of the bars forming the square meshwork into

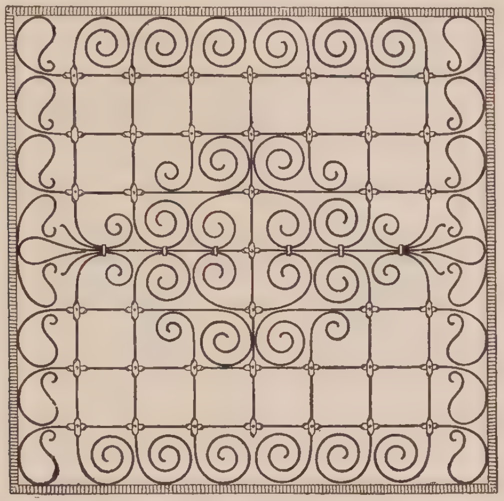


FIG. 14

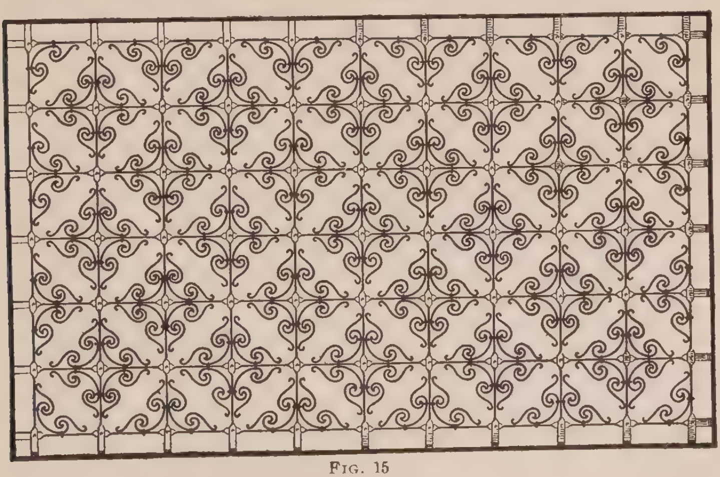


FIG. 15

scrolls, and adding other scrolls as may be desired. This can readily be seen by examining the designs shown, but to make it perfectly clear, some of the component parts of Fig. 13 (*a*) are shown separately. The small scroll *a* is shown separately at (*b*); the large central scroll *b* is shown at (*c*); the central division and loop *c* is shown at (*d*); and the small

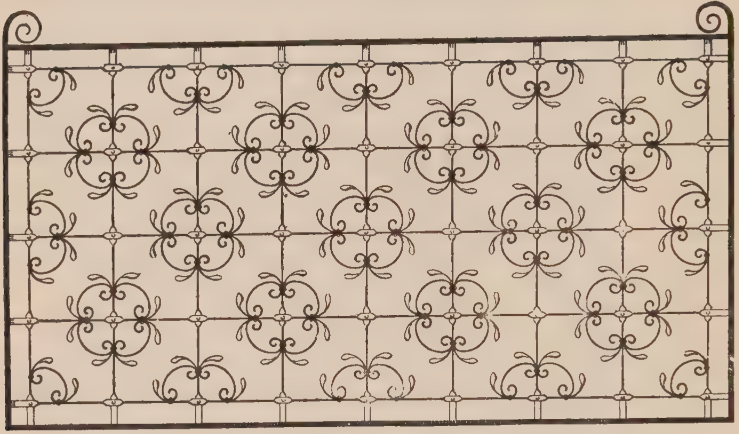


FIG. 16

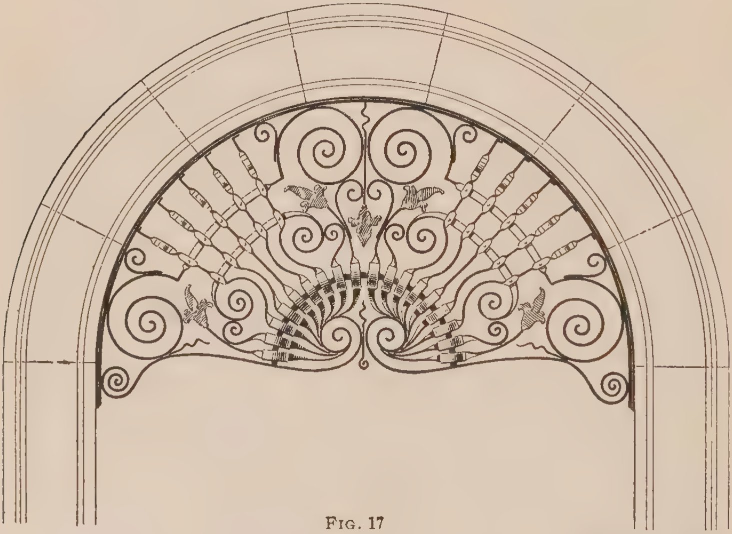


FIG. 17

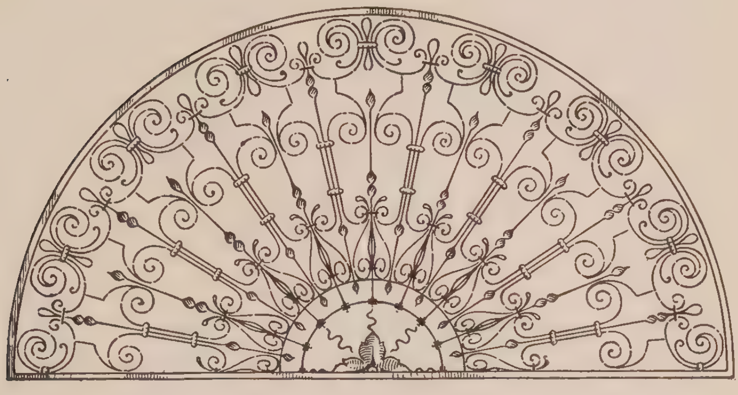


FIG. 18

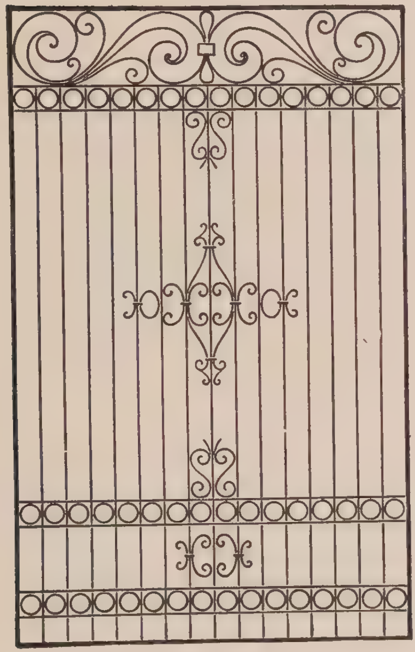


FIG. 19

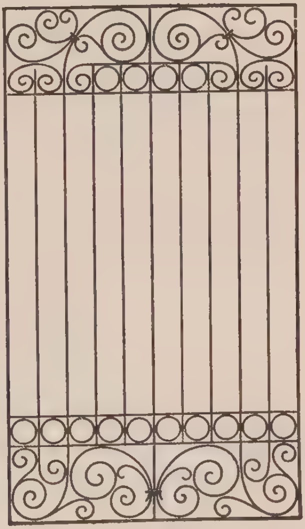


FIG. 20

scroll and ribbon *d* is shown at (*e*). These are all made of single pieces of iron.

The pattern shown in Fig. 15 is designed to produce a diaper effect, as is also Fig. 16, the latter being a more open pattern. All of these designs are for grilles made of light strips not over $\frac{1}{16}$ inch thick by $\frac{5}{16}$ inch wide, though at times heavier material may be employed. Figs. 17 and 18 are radiating designs suitable for arched window or door openings, but in other respects are precisely the same as the grilles just described.

In Figs. 19 and 20, the square mesh is abandoned, and the metal used is somewhat heavier, so that the long straight bars may be strong enough to resist the tendency to bend. There is no set rule for determining the size of iron of which a design should be composed, as this is governed principally by considerations of artistic fitness. If the iron is too thick to be readily twisted at the intersection, it may be half checked, as shown in Fig. 21; or, if one piece is wider than the other, the wide piece may be punched out to permit the narrower one to pass through it, as shown in Fig. 22.

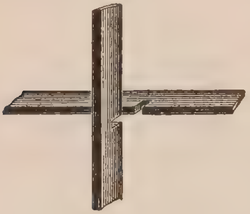


FIG. 21

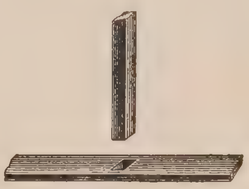


FIG. 22

8. Office Grilles.—The metal counter rails in banking houses, offices, etc., so far as the grille-work is concerned, are in no way different from the grilles heretofore described; but the arrangement of the supports, and the height and division of the rail, must all be proportioned to suit the special conditions of each case. Figs. 23 and 24 are examples of grilles made of cast and wrought iron. In Fig. 23, the rail and the posts are of cast iron, but the frame of the grille and the wicket gate and frame are of wrought iron. The grille is a simple basket pattern of ribbon iron twisted at the intersections and wrought into scrolls at the outside to form a border. The main scrolls of the wicket are finished with cast-iron rosettes. The rail has a cresting produced by extending the post with a finial ornament, and placing a scroll each side of it.

The design shown in Fig. 24 is more elaborate. The posts and rails are of cast iron, as in the former case, as well as the frame surrounding the wicket gate; but the entire screen is backed up with plate glass. The posts have a fluted band above the base, and just above this is a band, or circle, to carry out the line of the baluster rail of the screen. The entire grille of each panel is set in one frame, which is divided into two parts, the lower part forming a balustrade design, and the upper part a diaper; the loop scrolls of the diaper are ornamental with a pendant of leaves, as shown. The frame is separated from the rail, counter, and sides by button washers as shown. The plate-glass panels back of the screen are set in an angle-iron frame fitted with hinges

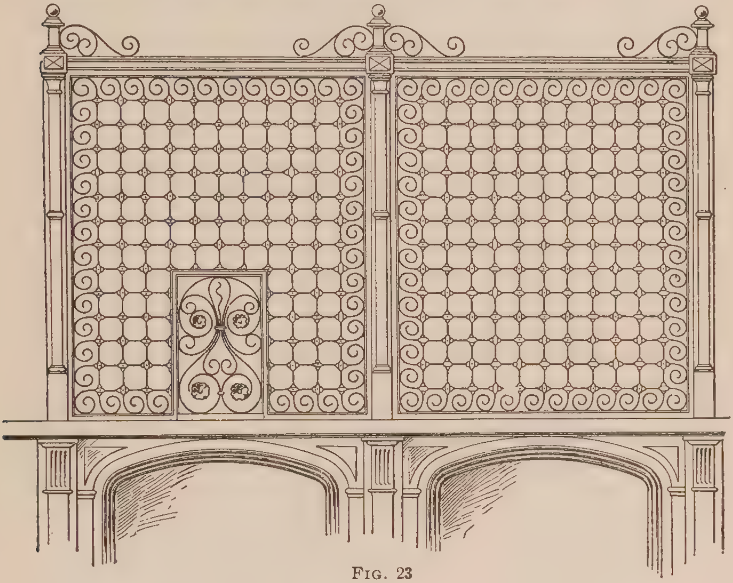


FIG. 23

that swing inwards, so that they may be opened to clean the glass. The wicket frame is designed with architraves and lintel, as would be any door or window. The change shelf under the wicket is made of heavy plate glass on a polished metal plate supported on two console brackets, and is fastened to the plate with countersunk screws through the metal plate. The head of the opening is ornamented with a cast-iron scroll and leaf, but the scroll at the junction of the frame and the baluster rail is of wrought iron, and is placed there to give rigidity to that point.

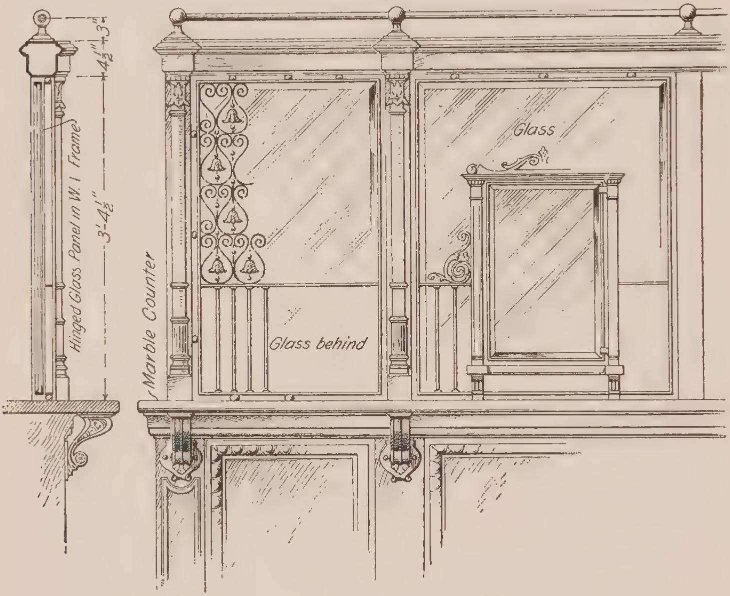
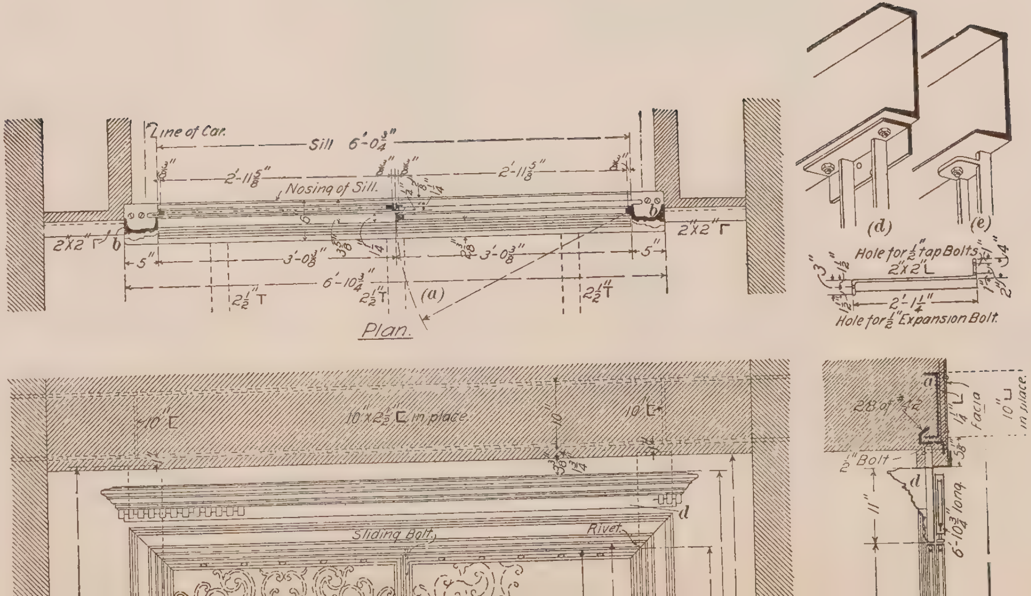
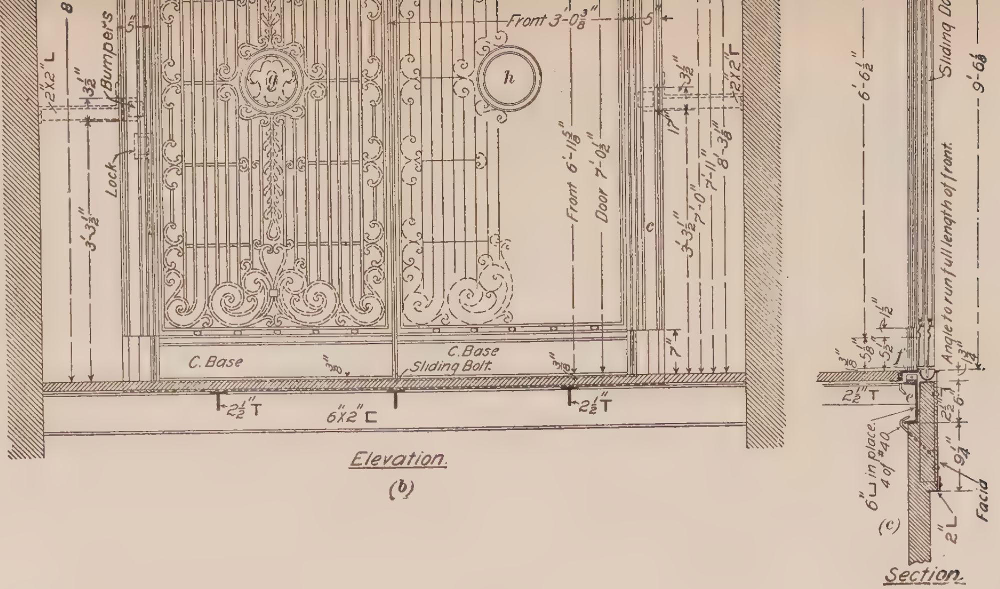


Fig. 24

The moldings of the rail at the top of the screen are broken around the post to emphasize the divisions of the screen. Over each of these points is a finial ornament, which also serves as a standard through which the brass upper rail passes. These examples represent the usual forms and outline of this class of work, but the details of the design will vary with each individual case.


Line of Car.
Sill 6'-0¾"
2'-11⅝"
2'-11⅝"
Nosing of Sill.
2"X2" ┏
2"X2" ┏
b
b
5"
3'-0⅜"
3'-0⅜"
5"
6'-10¾"
2½" T
2½" T
2½" T
(a)
Plan.
(d)
(e)
Hole for ½" tap Bolts
2"X2" L
2'-1¼"
Hole for ½" Expansion Bolt.
10" ⊏
10"X2½" ⊏ in place.
10"
10" ⊏
28 of #12
a
Facia
10" ⊐ in place.
½" Bolt
d
11"
6'-10¾" long
Sliding Bolt.
Rivet.
d



Elevation.
(b)

Section.
(c)

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FIG. 25

ELEVATOR ENCLOSURES

9. All the preceding examples of grille-work are suitable for use in elevator enclosures or any similar screen work, and their application to such work will now be considered. In Fig. 25 is shown an example of grille-work front for an elevator shaft. The shaft is formed by the main well of the building in the rear, and fireproof partitions on the sides, the front only being of grille-work. An angle iron or a channel is usually set across the front of the well at each floor, as shown at *a*, Fig. 25 (*c*), the top of which is generally 4 inches below the level of the finished floor of the story above, although the location of these beams, being a matter that is determined in connection with the general structural framework of the building, varies materially in different structures. The enclosure work should, of course, be made to suit the positions of these beams on which it is supported, and the important point is their relation to the finished floor level. In fact, the principal measurements necessary to lay out the work are the width between the partitions, the distance from the finished floor to the top of the beams, the depth of the beams, and the height from floor to floor (which will generally be the same as from beam to beam). Having these points determined, the position of the cast-iron jambs *b*, Fig. 25 (*a*), should be fixed. In this example, the whole opening is surrounded with a cast-iron architrave *c*, shown in the elevation (*b*), consisting of the jambs shown at *b* in the plan, over which is set the cornice *d*, standing independent and distinct from the partition. The jambs rest on top of the steel channel *e*, Fig. 25 (*c*), and are bolted to it at the bottom; while the top is run up and bolted to the bottom of the channel *a*, as the partition itself affords no support. The upper portion of the jamb is checked back from the point where the architrave is mitered, to the bottom of the beam above, in order to permit the cornice to pass in front of it, and to permit it to be enclosed in the partition. The top connections may be made by riveting to the head of the jamb a short piece of angle iron, to project each side of

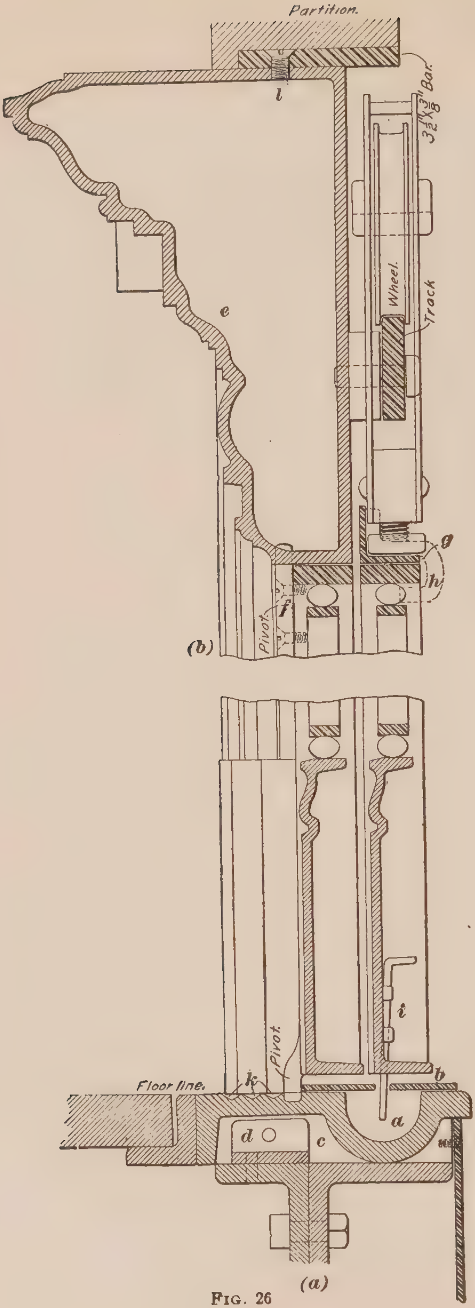

Partition.
$3\frac{1}{2}'' \times \frac{3}{8}''$ Bar.
l
Wheel.
Track
e
g
h
f
Pivot.
(b)
i
Pivot.
k
b
Floor line.
a
d
c
(a)

FIG. 26

the jamb, as shown at (*d*); or, the top of the jamb may be cast with a flange, or lug, about $\frac{1}{2}$ inch down from the top, as shown at (*e*). The $\frac{1}{2}$-inch clearance permits the jamb to be shortened a trifle if necessary, when fitted to its position.

The jambs being set perfectly plumb, the sill *f* is then put down, and, as will be seen in the section (*c*), the edge next to the floor is turned down about $1\frac{1}{2}$ inches, to form a flat surface for the flooring to finish against. The angular grooves shown at *k* in the large detail of the sill, Fig. 26(*a*), give a better foothold than if the surface were smooth; the deep groove *a* in the same detail is for the bottom guide of the sliding door to travel in, and is made ample in width, and closed in on each side with a strip of wrought iron *b*, to permit of adjustment in case the cast sill is not set exactly true. The wrought-iron plates are also advantageous, inasmuch as they serve better to keep the door in its proper place and reduce the friction surface to the narrow edges of the strips only. As the side of the sill next to the shaft is not deep enough to reach to the beam, upright ribs *c* are cast about 3 feet apart along the under side; and on one side of each of these ribs is riveted a piece of angle iron *d*, which is bolted to the beam. The cornice is a hollow casting, as shown in Fig. 26 (*b*). It is open at the ends where the extensions of the side jambs pass behind it, and it is mitered with the architrave at the corners where it joins and is bolted to the jambs and architrave with countersunk screw bolts. The cornice is fastened to a bar with screw bolts, as shown at *l*, and the bar in turn is bolted at each end to the jambs.

10. In Fig. 27 is shown a plan and horizontal section of the front of the enclosure. The strap brackets *a* are of 2″ × 2″ angle iron, and are so placed as to brace the opening laterally. They are bolted to the structural column with expansion bolts, and to the architrave with countersunk screw bolts. The webs *b* of the architrave are thick enough to provide a firm and sufficient hold for the tap or screw bolts securing the door stop. These stops are fitted with a rubber cushion *c*, which takes up the recoil and noise of the door when operated.

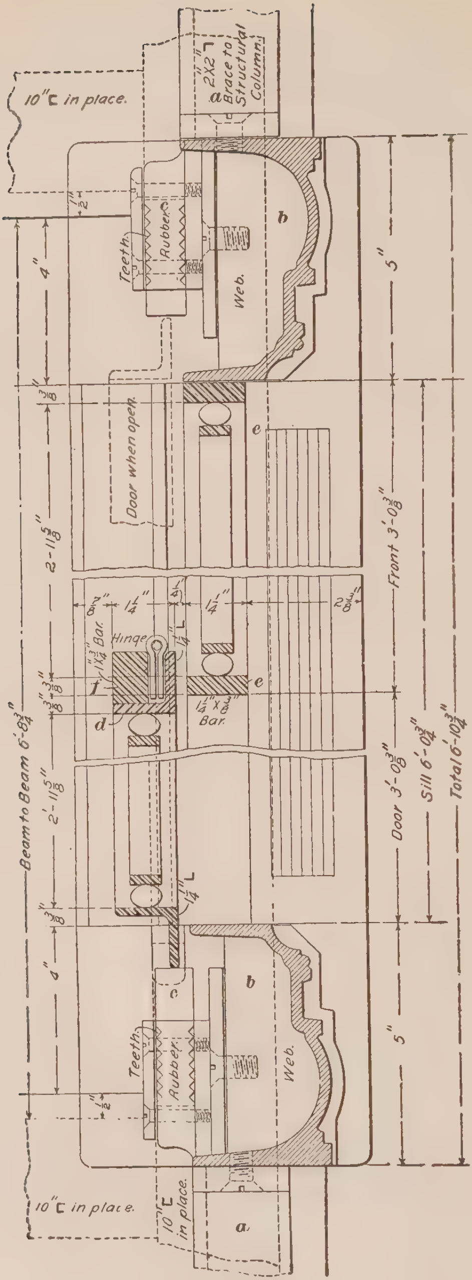

10" ⊏ in place.
a
2"X2" ⅂ Brace to Structural Column.
b
Web.
Teeth.
Rubber.
1/2"
4"
3/8"
Door when open.
2'-11 5/8"
7/8"
1 1/4"
1/4"
1 1/4"
2 3/8"
Hinge
3/4"X 3/4" Bar.
1 1/4" L
f
d
e
c
1 1/4"X 3/8" Bar.
Front 3'-0 3/8"
Door 3'-0 3/8"
Sill 6'-0 3/4"
Total 6'-10 3/4"
5"
Beam to Beam 6'-8 3/4"
2'-11 5/8"
1 1/4" L
10" ⊏ in place.

FIG. 27

By referring to the elevation, Fig. 25 (*b*), it will be observed that the grille-work is divided into two large panels, one being the door *g*, and the other a pivoted panel *h*. The frame of the door is composed of angle irons, as shown at *d*, Fig. 27, and the frame of the pivoted panel, of flat bars, as shown at *e*. The pivots are fastened to these bars with screw bolts, as shown at *f* in Fig. 26 (*b*). On the sliding door is a bar shown at *f*, Fig. 27, to which the door is hinged. This bar carries at the bottom a guide, which fits in the groove of the track, and is secured at the top to the angle iron *g*, Fig. 26 (*b*), which is a slight extension of the door frame. The door is held in place by the guide bolt *i*, Fig. 26 (*a*), and the panel, by sliding bolts. The reason for this arrangement is to facilitate and make possible the entrance to the elevator of large pieces of furniture; in such a case, the whole front may be swung open by first drawing the sliding bolts in the pivoted panel, then drawing the guide bolts and pushing back the sliding door to its full extent. Both sections are then swung open, the bar and the angle iron remaining attached to the hinges. When used under ordinary conditions, the sliding door is held in place and firmly attached to the hanger by the clips shown dotted at *h*, Fig. 26 (*b*).

11. The hanger consists primarily of a pair of wheels running on a track, from which the door is suspended. These wheels are alike and are set about 12 inches from each end of the door, the position varying somewhat in different doors. Fig. 28 shows the principal features of this hanger, which is patented. The track *a* shown in the section (*b*), on which the wheels run, is fixed to the back of the cornice at each end by cast-iron supporters *b*, Fig. 29, which should be set perfectly level. The track, with the wheels on it, is then put in position, and the bolts b' are loosely screwed through the slotted holes in the end. If it is found necessary to further adjust the track, the screws *c* are for that purpose, so that it can be easily set level; then the bolts b' are to be screwed up tight. On the arrangement

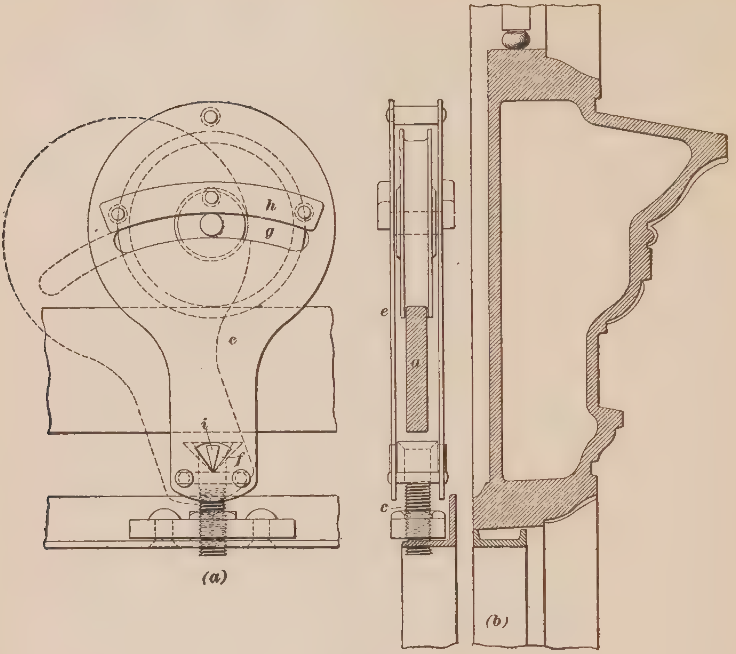


FIG. 28

Note:
After Leveling Track with Adjusting Screw b' tighten Bolt to its limit.

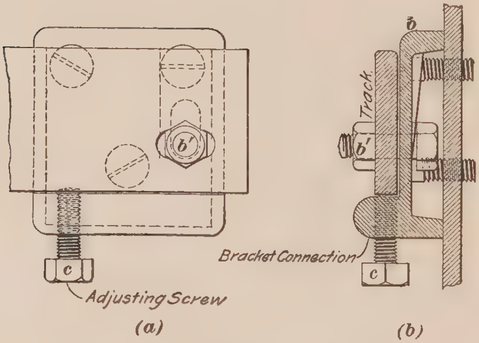
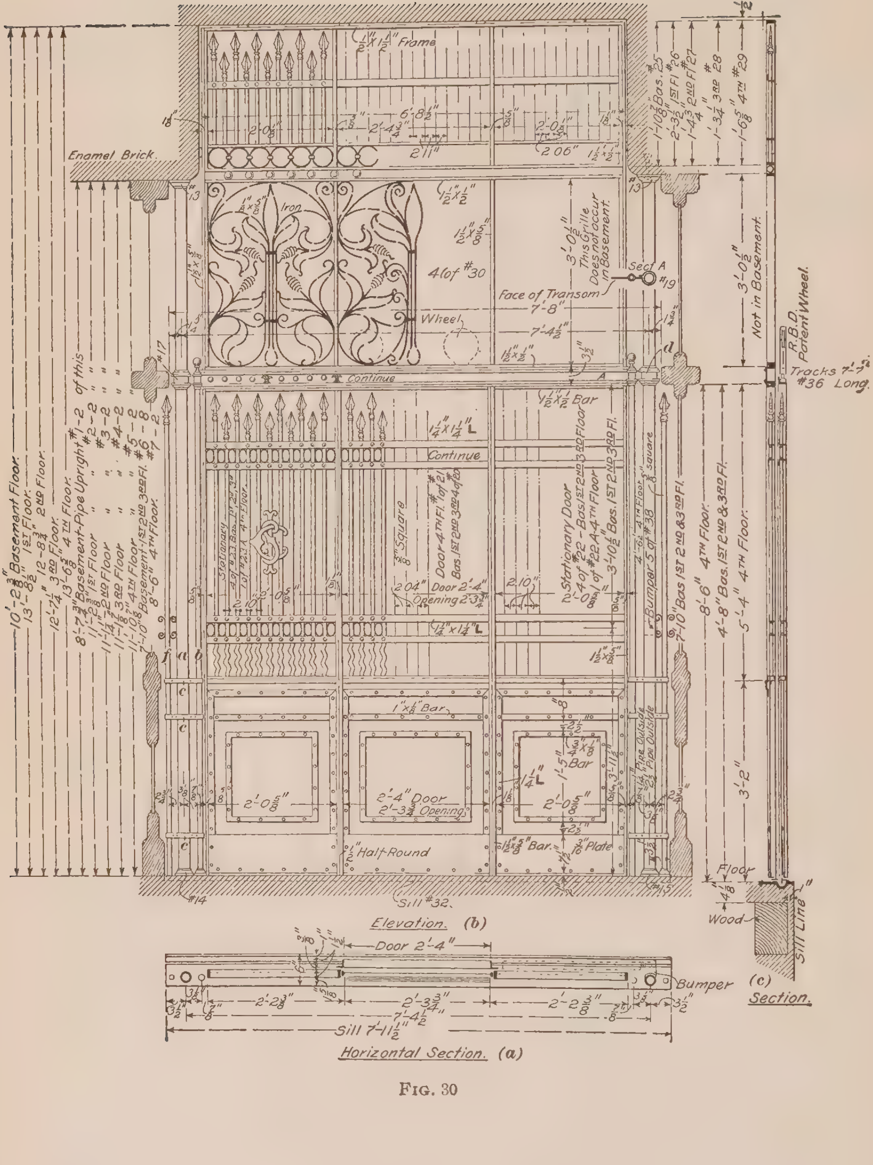


FIG. 29

of the sides that enclose the wheels depends the easy gliding motion. These sides *e*, Fig. 28, are punched out of solid steel. At the lower end, there is a **V**-shaped hole *f* and across the center is a slot *g* reinforced by a steel strap *h* in which the axle of the wheel travels and revolves, as shown in Fig. 28 (*a*). The slot is an arc of a circle whose center is the lower angle of the **V**-shaped hole, and the door is suspended from the knife-edge bearings *i* resting in this **V**. When the door is at rest, the wheel is in the position shown by the full lines, and as it is pushed along, the sheaves gradually swing over to the position shown by the dotted lines, the center of the wheel always remaining over the point of suspension. This prevents any rubbing motion at any point, as the axle of the wheel is not bound in any way, but simply rolls in the slot, and it is evident that the friction at the point from which the door hangs is practically nothing. If it is found necessary to raise or lower the door itself, this may be done, after everything is in position, by turning the suspending bolts *c*, which are squared at the neck to afford a hold for a key or wrench.

12. The construction of the enclosure, as well as the design shown in Fig. 30, differs considerably from that of the preceding example. With the exception of three details, it is entirely of wrought iron, these exceptions being the sill, the transom, and the molding at the top of the lower panels. By referring to the plan (*a*) and elevation (*b*) of the small scale detail, Fig. 31, also the section (*d*), the surroundings governing the design may readily be seen. The main support of the screen is a round bar or column, shown at *a*, Fig. 30, which consists of a $2\frac{1}{2}$-inch wrought-iron pipe fitted with a cap and base. The top is secured to the soffit of the brick arch over the partition with an expansion bolt, and also to the cast-iron sill at the floor level. The grille screen is separated from this column by a small post *b*, which forms the sides of the grille frame and is finished with base and finial. It is fastened to the main column *b* by collar straps *c* on the lower part, and by the transom extension *d*



Elevation. (b)

(c) Section.

Horizontal Section. (a)

FIG. 30

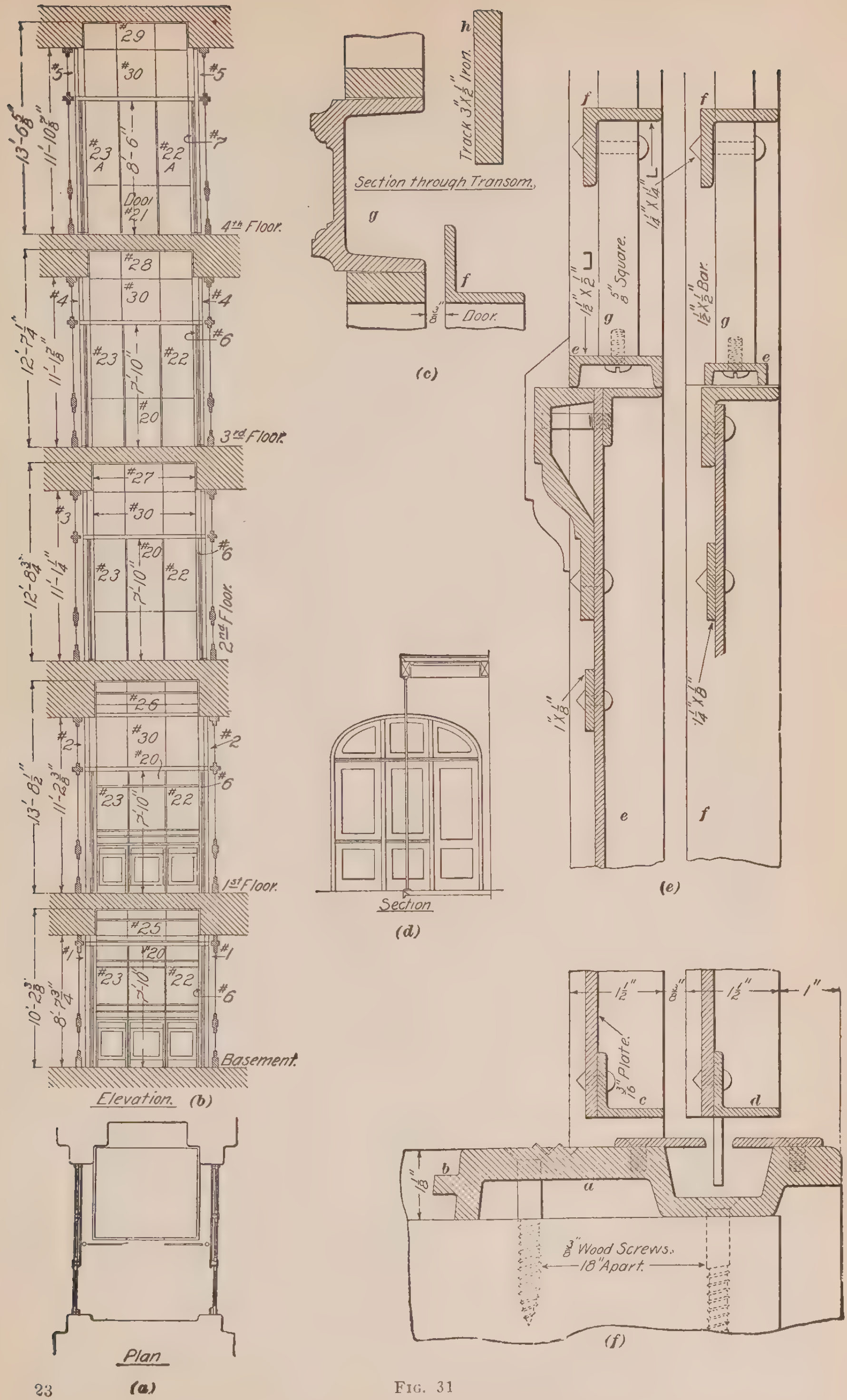

#29
#30
#5
13'-6 5/8"
11'-10 7/8"
#23 A
8'-6"
#22 A
#7
Door #21
4th Floor.
#28
#4
12'-7 1/4"
11'-1 1/8"
#23
7'-10"
#22
#6
#20
3rd Floor.
#27
#3
12'-8 3/4"
11'-1 1/4"
2nd Floor.
#26
#2
13'-8 1/2"
11'-2 3/8"
1st Floor.
#25
#1
10'-2 3/8"
8'-7 3/4"
Basement.
Elevation. (b)
Plan
(a)
h
Track 3"X1/2" Iron.
Section through Transom.
g
f
3/8"
Door.
(c)
Section
(d)
f
L 1 1/4"X1 1/4"
1 1/2"X1/2" ⊐
5/8" Square.
g
e
1"X1/8"
e
1 1/2"X1/2" Bar.
1/4"X1/8"
(e)
1 1/2"
3/8"
1 1/2"
1"
3/16" Plate.
c
d
b
1 1/8"
a
3/8" Wood Screws.
18" Apart.
(f)

Fig. 31

at the top. The jambs of the door opening are formed of half rounds, to correspond to the post *b* and to strengthen the center of the screen. The space between the post and the partition is fitted with a small bar *f* to fill the space between the column *a* and the side walls. The sill shown in detail in Fig. 31 (*f*) has a tongue *b* cast on it to receive the finished floor, which is grooved to fit over this tongue and thereby make a snug and unyielding joint. The stationary panels of the screen each side of the door have a dado panel in plate iron, and grille-work above; the same treatment being used in the door.

13. A section of the screen, Fig. 30 (*c*), shows the sliding door on the inside of the shaft and the hanger above. Fig. 31 (*f*) shows a section through the cast-iron sill and the method of screwing it to the wooden under floor. At *d* is a section of the bottom of the sliding door, while at *c* is the fixed panel. The sections of the upper moldings on the dado panel of the door and screen are shown in Fig. 31 (*e*); and at *g* is seen the elevation of the lower part of the bars of the grille, and the screw that secures each of them to the channel iron forming the surrounding and protecting frame. In Fig. 31 (*c*), a section of the transom bar is shown at *g*, a section of the top of the door at *f*, and the track on which it slides at *h*. The enclosure on each story being similar in design, it is not necessary to detail each one. A general plan and elevation is given in Fig. 31 (*a*) and (*b*), and one detail plan and elevation in Fig. 30, on which the varying dimensions of all the stories are marked. Each piece is numbered, and the quantity is also noted on these drawings. In all cases, the drawings are accompanied by a list or schedule.

14. The general construction of all elevator enclosures is practically the same as the examples given in the preceding articles and further details are unnecessary. In the enclosure screen shown in Fig. 32, the architrave is of cast iron, the general outlines and form of which are designed to correspond with the adjoining trim. This architrave is

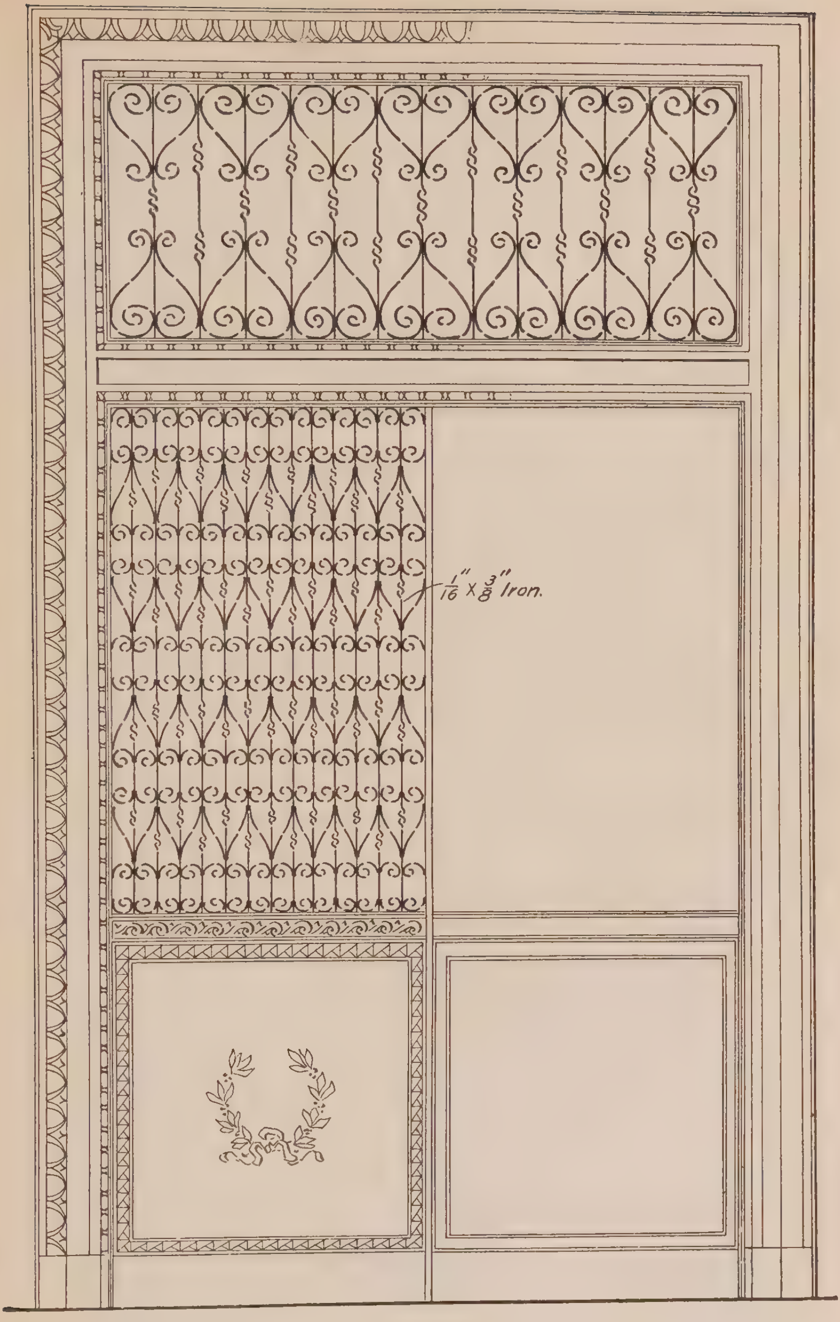


FIG. 32

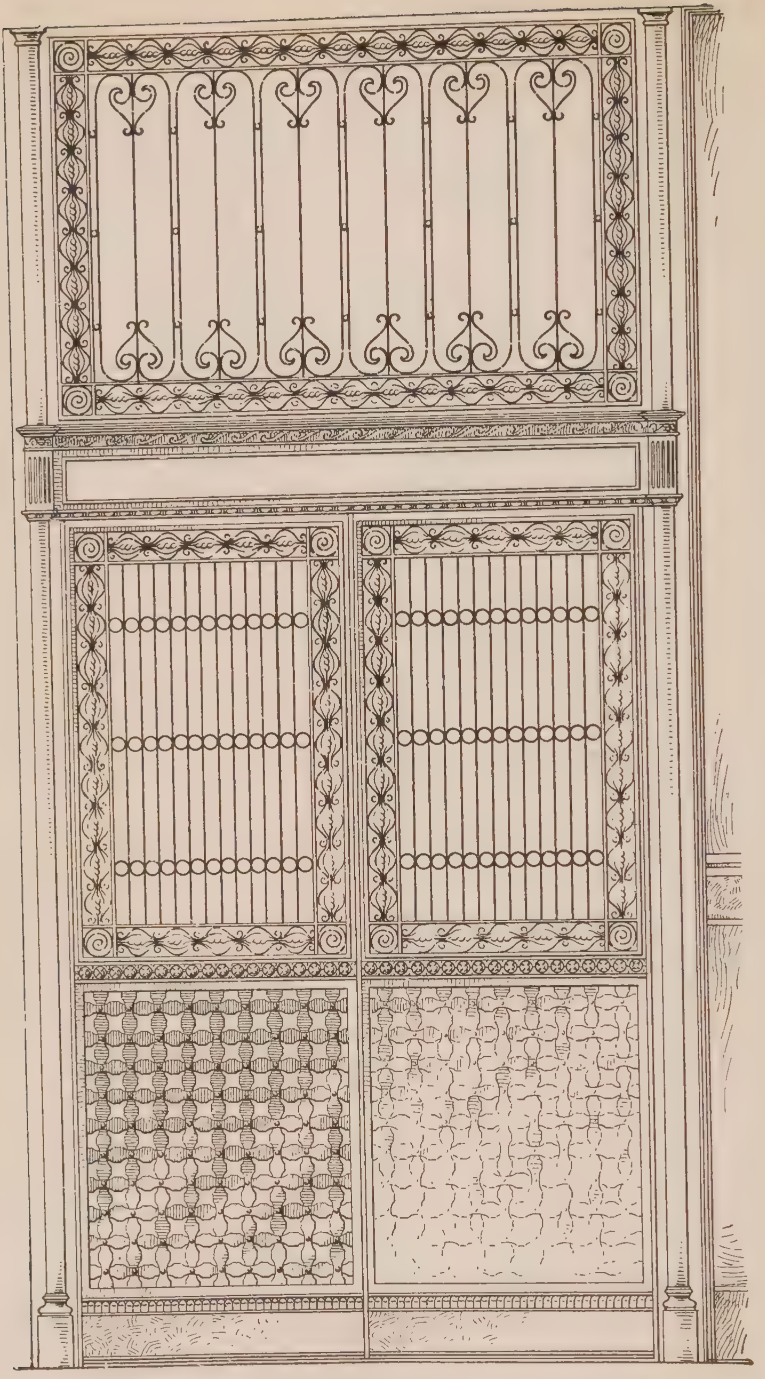


Fig. 33

decorated on the jamb side with a spool-and-spindle fillet mold, and on the outer edge with an egg-and-dart echinus molding. The dado panel is of sheet iron surrounded with a tooth molding, and the center is decorated with a wreath of myrtle leaves, berries, and ribbon in wrought or cast iron. The grille of the door is much closer than the transom grille, thus giving a heavier and close effect in the proper place. Both these grilles are formed from $\frac{1}{16}'' \times \frac{3}{8}''$ strap iron set with the edge to the front, the very open portions being relieved by twisting the bars so as to produce a spiral, showing the full width of the bar to the front.

15. In Fig. 33, the whole screen is formed of wrought iron, except the transom bar. This design presents several very agreeable and pleasing features; it is well balanced, and the transition, which should always be studied in design, from the heavy effect in the dado to the light area in the transom, is here well defined. The dado is especially good, as it combines protection, good design, and cheapness. The pattern, which is a diaper, is made of the usual basket strap work with the edges cut to the form shown. The rail is not too heavy, and shows a molding with a rosette-and-leaf decoration. The filling of the panel is of a series of bars well braced and bound together with three rows of rings. The transom bar—the only piece of cast iron—is finished at the ends with fluted and molded collar bands, through which the columns supporting the screen pass. The transom grille border is a repetition of the door grille, and the center is composed of six very open panels, separated by small button washers, thus completing the screen.

16. Fig. 34 is given as a fine example of wrought iron and cast iron combined. The large pilasters break the long stretch of grille-work into bays, at the same time serving to cover and decorate the plain structural-steel columns that are hidden behind them.

17. Ornamental iron elevator enclosures are sometimes combined with other materials, such as marble. Fig. 35 is a good specimen of this treatment. The white squares seen

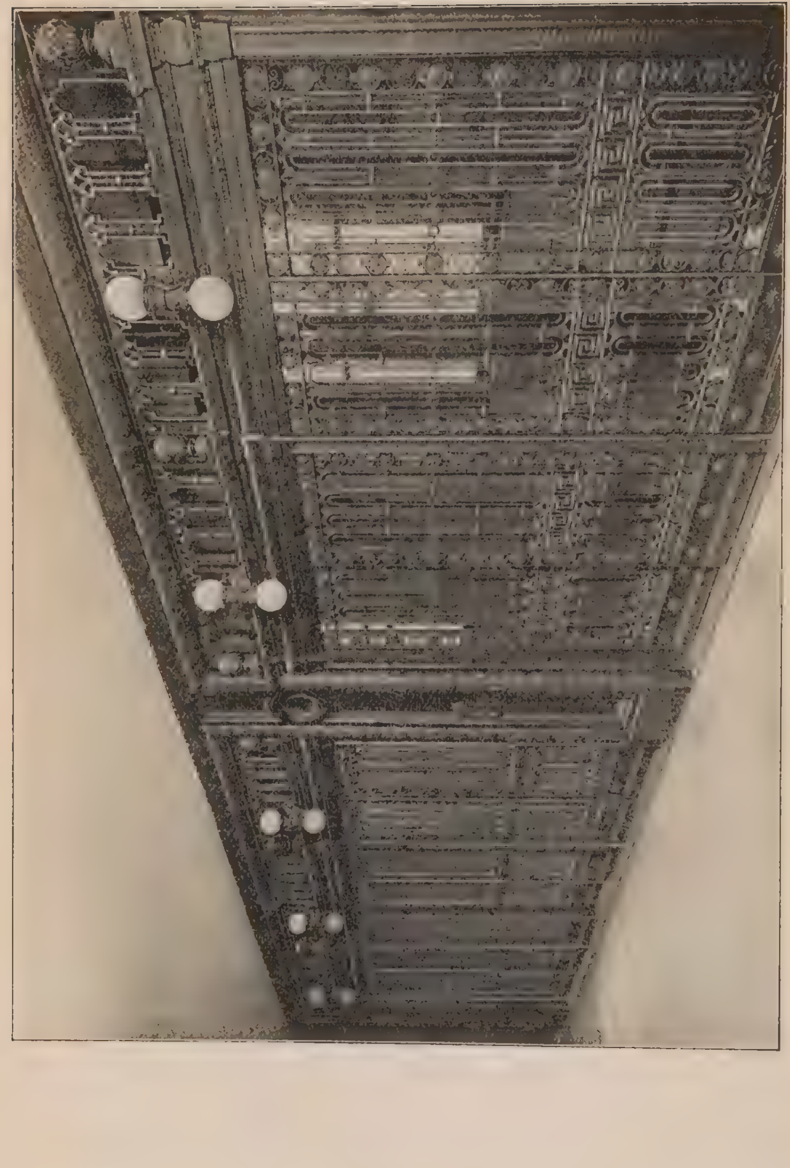


Fig. 34

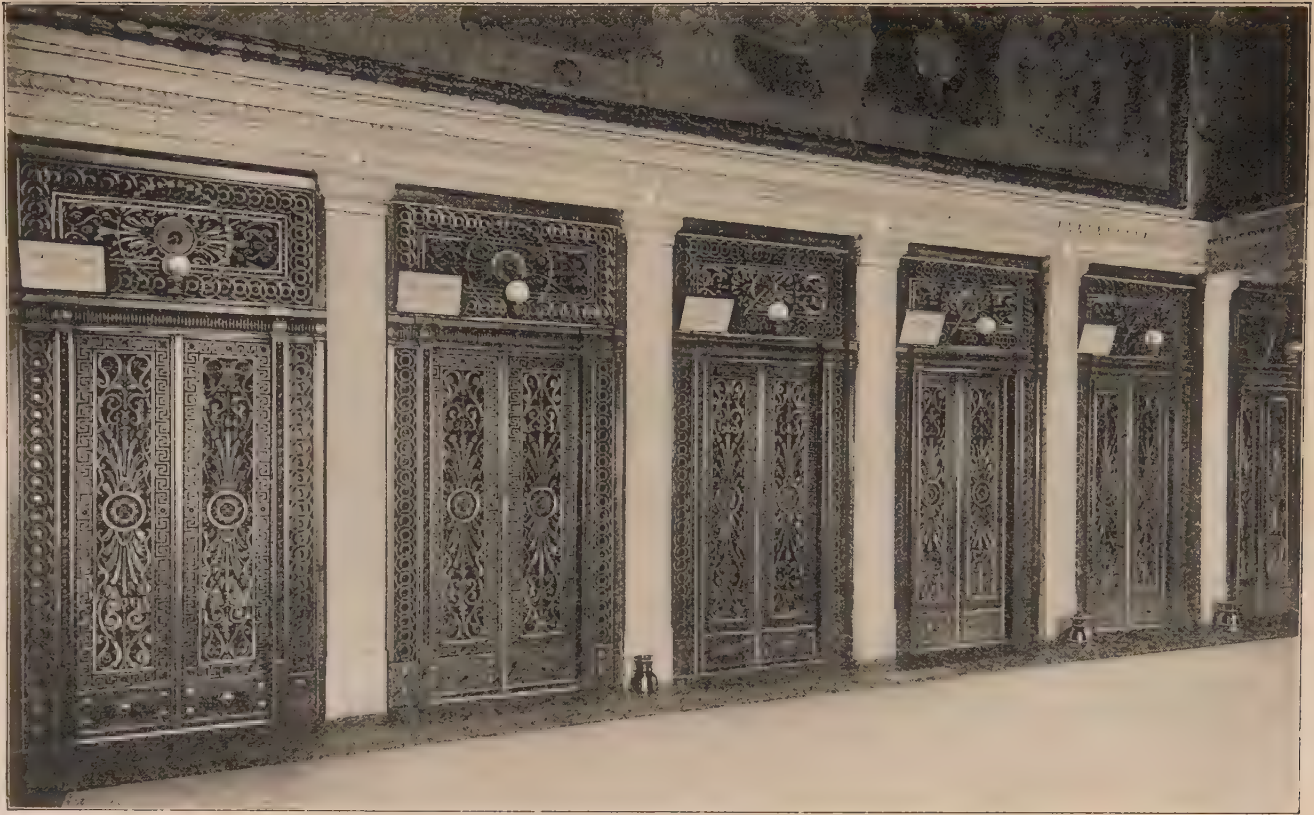


FIG. 35

over the doors are merely notice boards placed there for the direction of the public. When it is known in advance that

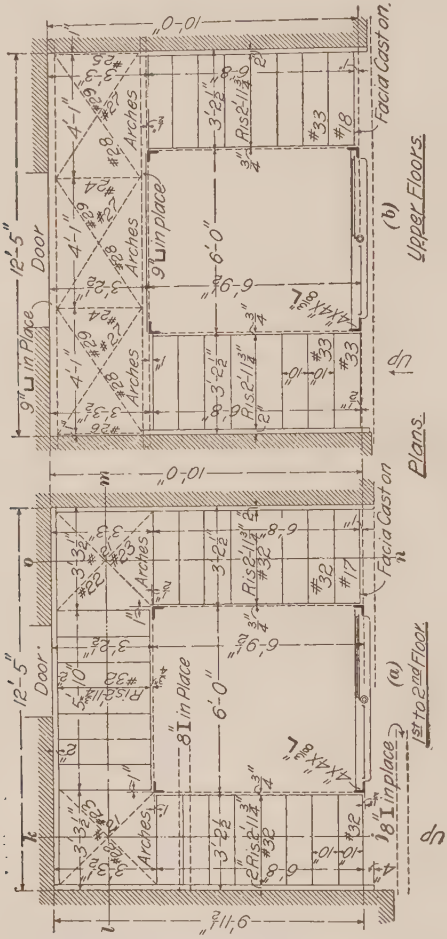


Fig. 36

such notices are likely to be needed, it is better to form a suitable place for them in designing the transom grille.

COMBINED ELEVATOR AND STAIR SHAFTS

18. In fireproof buildings, it is a common practice to combine the elevators and stairs in one shaft. In such cases, the elevator usually occupies the center of the shaft, and the stairway is constructed around it. Such a combination is shown in plan in Fig. 36, where the arrangement of stairs and elevator shaft on the first floor is shown at (*a*), and on the upper floors at (*b*). A 6′ × 6′ 9½″ elevator shaft is thus provided, around three sides of which rises a stairway 3 feet 2½ inches in the clear. So far as the details of the stairs are concerned, they are precisely the same in principle as those described in *Ornamental Metal Work*, Part 1; the wall strings are first set in place, then the face strings (which in this case are the well strings), and finally the risers and treads. The well strings, however, have to be considered with the elevator shaft, as they form a part of that structure; and the details of the grille-work screen around the elevator shaft should include a treatment that will take the place of a balustrade on that side of the stairs.

The elevations of the wall strings, the outside strings, and the sides and back of the enclosure, also the front elevation of the enclosure, are shown in Fig. 37 (*a*), (*b*), (*c*), and (*d*). The grille-work on the first story is of brass, and on the stories above, of iron.

19. As in the previous examples of stair work, the first procedure is to fix the number of risers and the width of the stairs. The height, as shown in Fig. 37 (*a*), is 14 feet 8¼ inches between the first and second stories; and to determine the number of risers, the size of the well hole, as well as the approximate space that the elevator will occupy, should be considered, though the latter may be modified to work out the stairs. It will be seen that twenty-six risers each 6.77 inches high, counting from top to top of the treads, gives nine risers each side of the well and eight at the back. This will permit the treads to be 10 inches wide on the sides and back, all finishing nearly symmetrically at the corners. The face of the first riser leading down the stairway, as shown in Fig. 36 (*a*), is ½ inch from the corner of the angle-iron frame of the well and the ninth riser is 1 inch from the corner of the corresponding angle at the back of the shaft. The upper part of the opposite side is similar, and the run at the back has the tenth and seventeenth risers, each 1 inch back of the angle iron, thus in each case allowing sufficient room for the finished tread to stop inside the edge of the angle. In planning any stair that is broken by

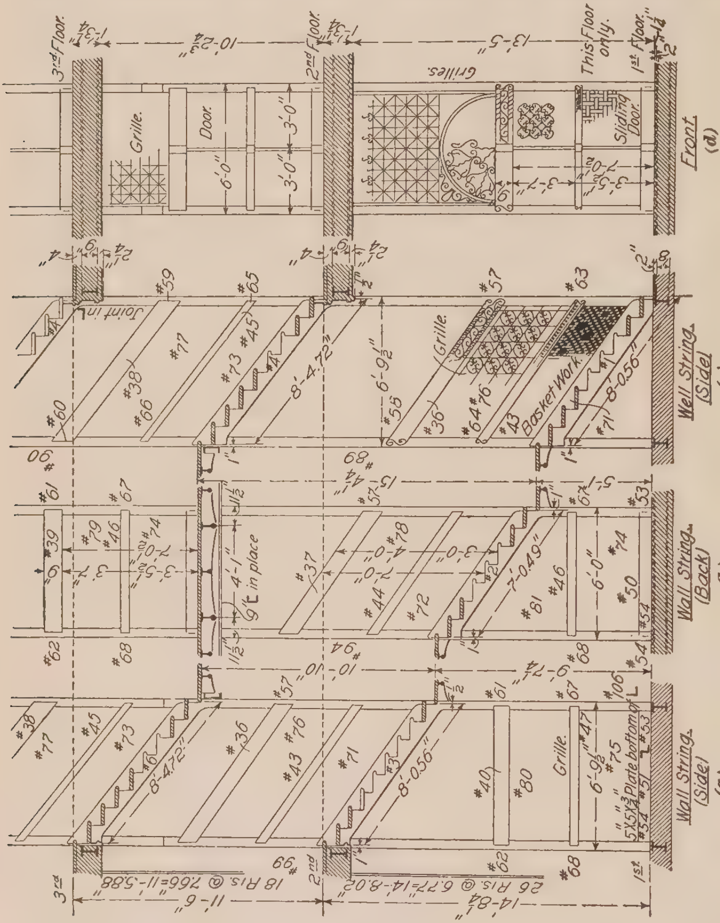


FIG. 37

intermediate platforms, the starting riser of each section should, if possible, be kept the same distance from a fixed point; in this example, these points are represented by the angles at the corners of the well. Circumstances may arise, as in the present case, when this arrangement is not possible, and then the space is divided as equally as possible.

The upper stories being less in height than the first story, fewer risers are required; and, by making them 7.66 inches high, the plan of the stair on each side of the well remains the same as the first story, while at the back the platform extends across the full width of the well. In fact, the stairs in every case should be planned as a whole, and not simply flight by flight.

20. The plans being determined, the wall and outside, or well, strings, and the sides and back of the enclosure should be laid out on the section lines *j k*, *l m*, and *n o*, shown in Fig. 36 (*a*), the developments of which are shown in Fig. 37 (*a*), (*b*), (*c*), and (*d*), and in Fig. 38 (*a*), (*b*), and (*c*). The elevation of the front is also shown in Fig. 37 (*d*). In most stairs, the platforms are of slate or marble, and must be supported at the center or diagonally by either cast- or wrought-iron ribs or arches, as indicated by the dotted lines shown on the plans, Fig. 36. The development and details of the parts of the enclosures and stairs are shown in Fig. 39; (*a*) shows the head of the outside string in sectional elevation and plan at the first platform, between the first and second stories; (*b*), the foot of the outside string in sectional elevation and plan at the first platform, between the first and second stories; (*c*), the wall string in sectional elevation and plan at the first platform, between the first and second stories, and an elevation of the arch rib supporting the platform and the springing block to which the rib is bolted. At (*d*) is shown the sectional elevation and plan of the head and foot of the outside string, with the enclosure of basketwork and grille as they exist in the upper stories, and (*e*) shows the sectional elevation and plan of the wall string of the same run. At (*f*) is shown a sectional elevation and plan of the head and foot of the outside string on all the platforms and landings of the upper stories. At (*g*) is shown the wall string and the platforms and landings of the same run. In

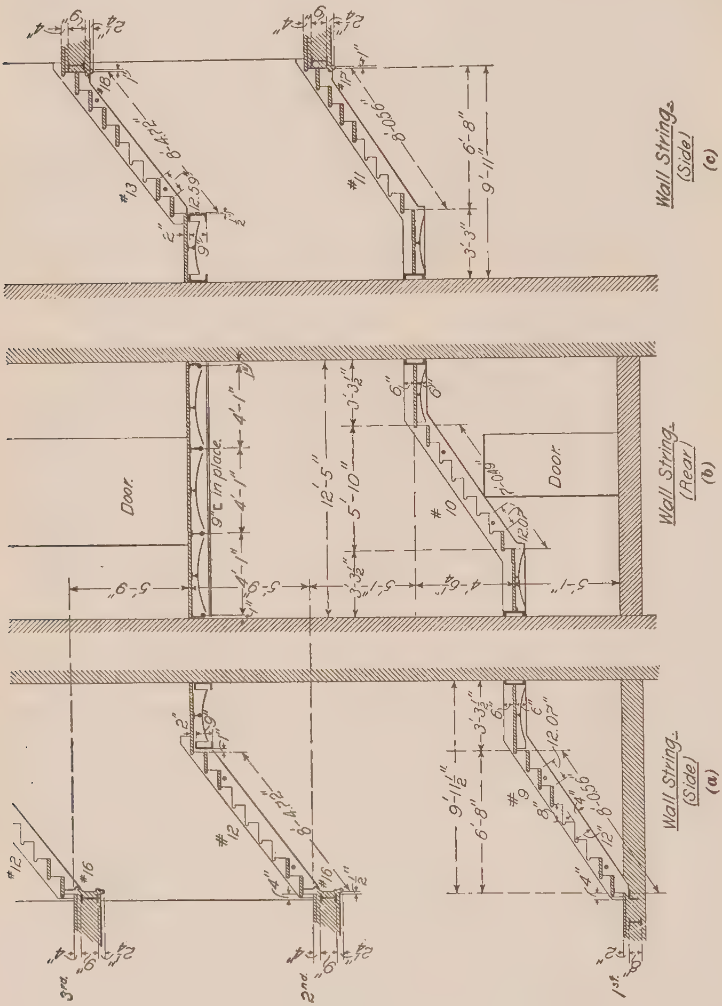
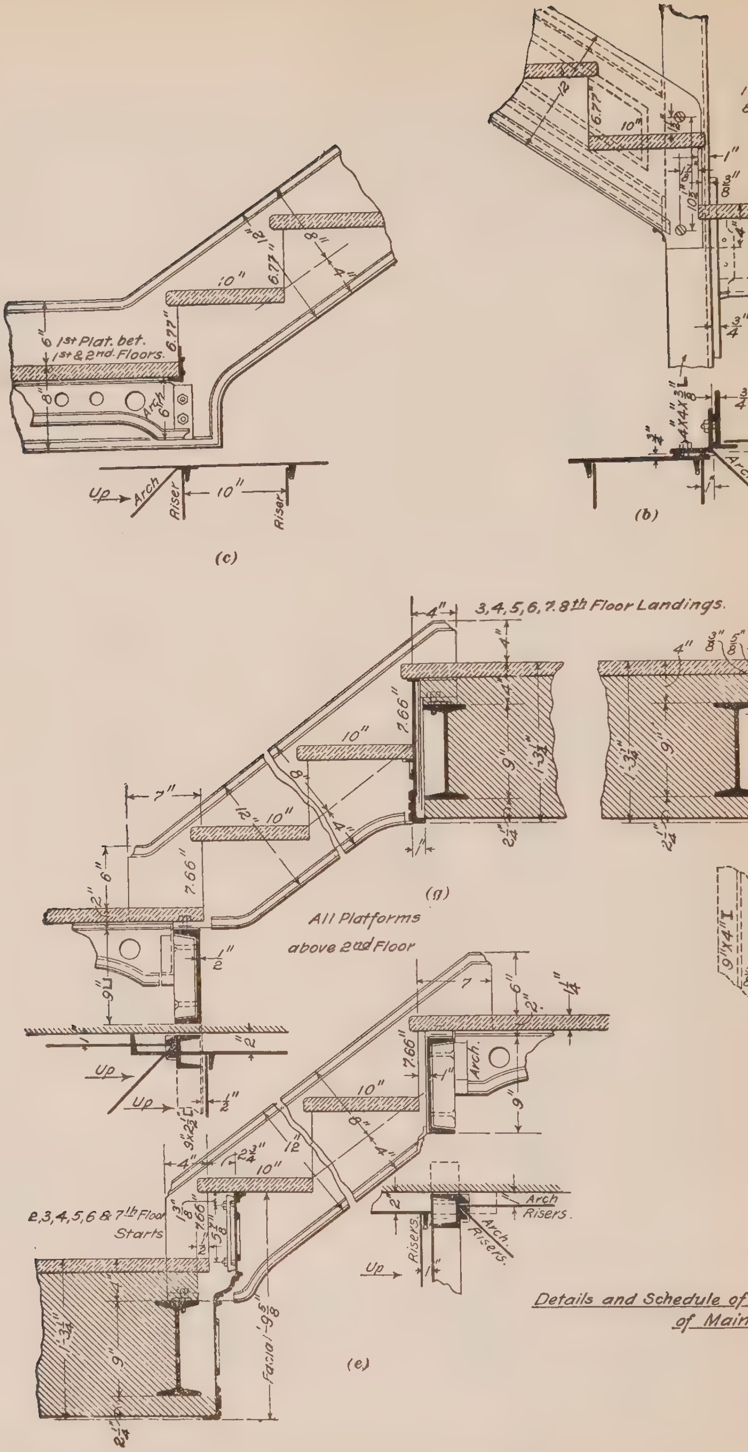
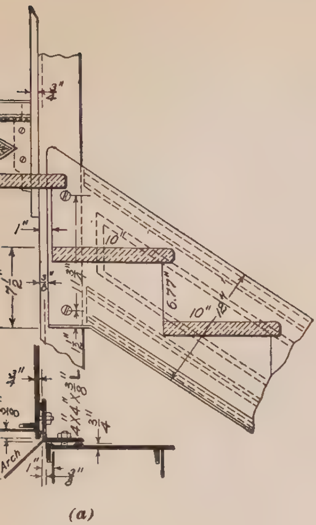


FIG. 38

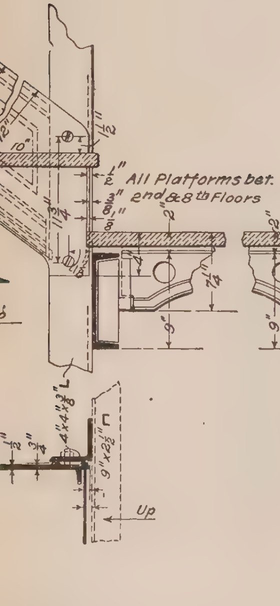
Fig. 40 is shown the elevation and section of the rib arches that support the platforms. The ends are checked out $\frac{3}{4}$ in. × 1 in., where they rest on the springing blocks, as shown.



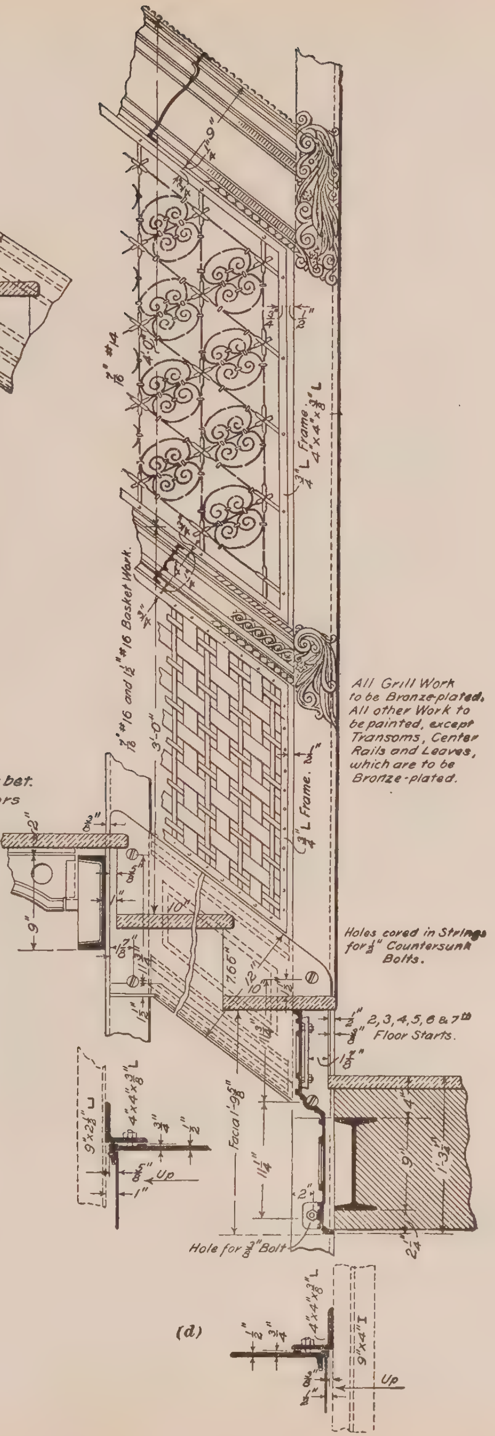
Details and Schedule of
of Main



(a)



Strings



All Grill Work to be Bronze-plated. All other Work to be painted, except Transoms, Center Rails and Leaves, which are to be Bronze-plated.

Holes cored in Strings for ½" Countersunk Bolts.

2, 3, 4, 5, 6 & 7th Floor Starts.

Hole for ⅜" Bolt

(d)

Fig. 40 shows at (*a*) the plan of these platform arches for the first story, and at (*b*) for the upper stories, while the springing blocks that support these ribs are shown at (*c*).

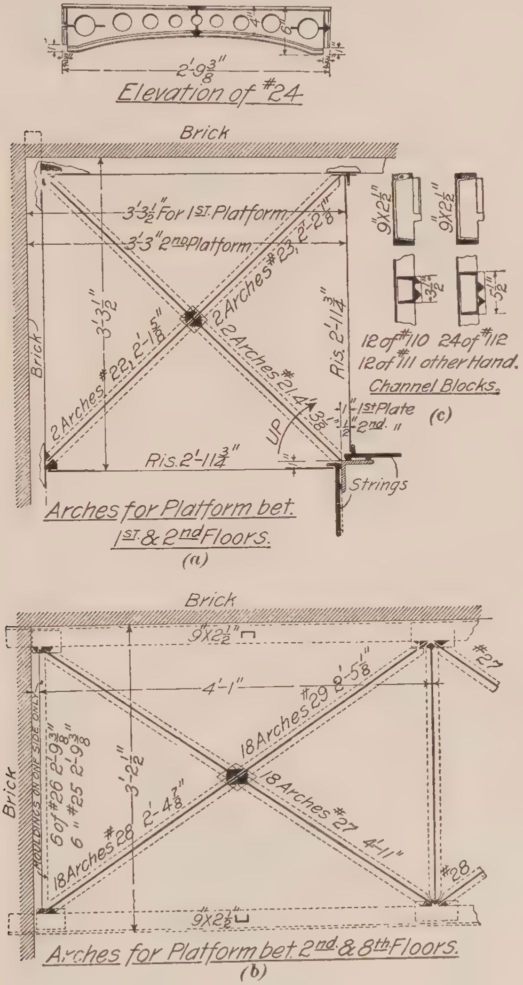
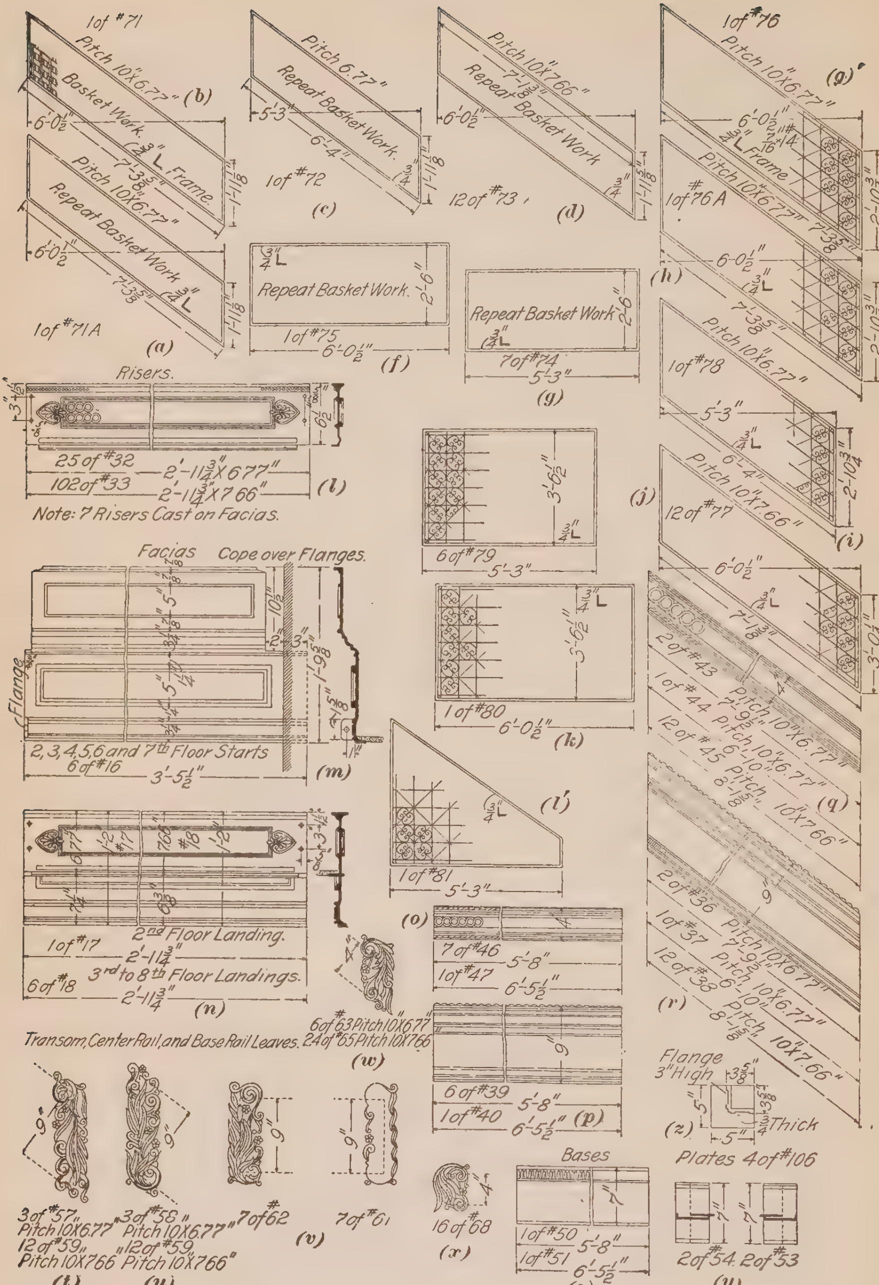


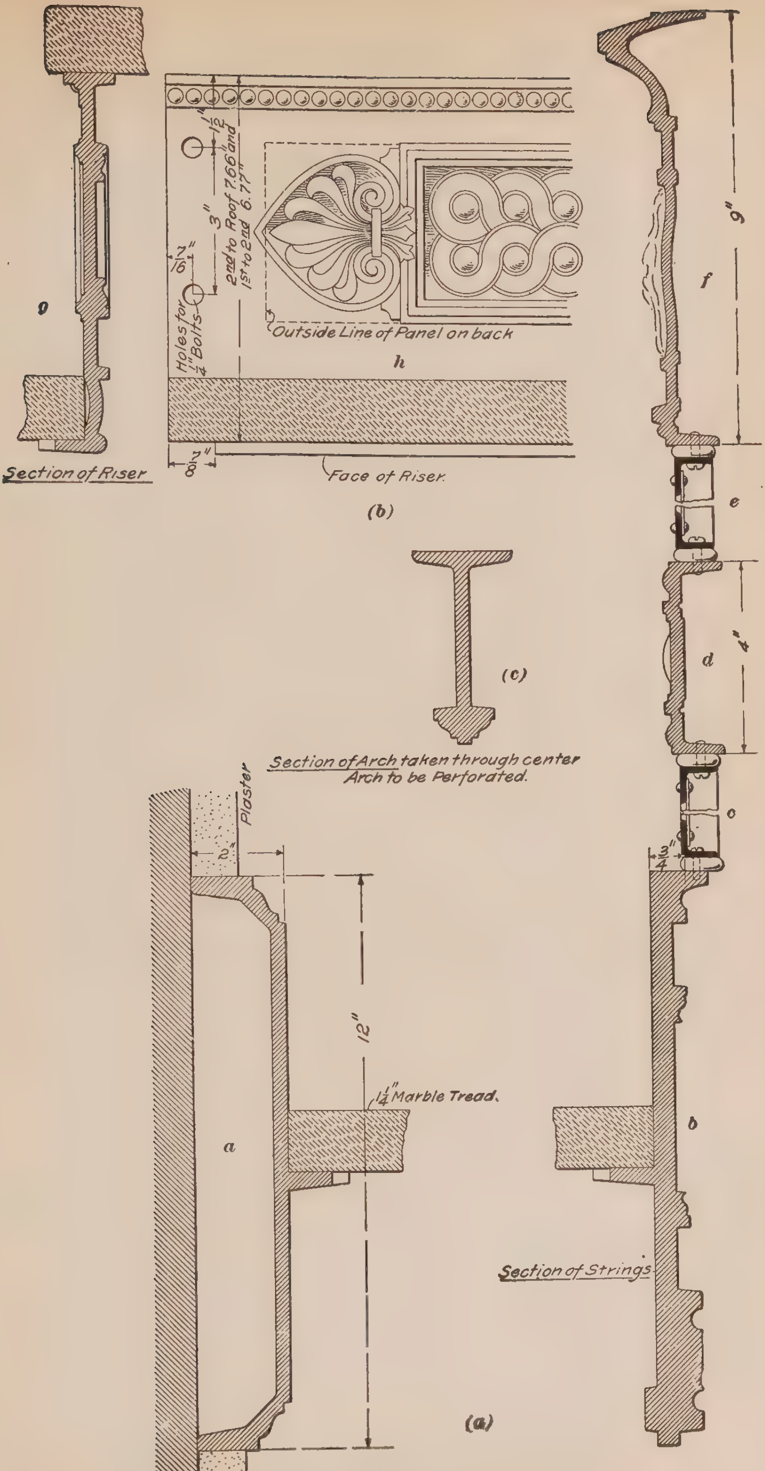
FIG. 40

They are cast channel shape, with the web, or socket, and the lug on the face. The upper drawings at (*c*) show these blocks in elevation, the lower drawings in section.



1 of #71
Pitch 10"×6.77" (b)
Basket Work.
6'-0½"
2¾" L Frame.
7'-3⅝"
1'-11⅛"
Pitch 10"×6.77"
Repeat Basket Work
6'-0½"
7'-3⅝"
¾" L
1'-11⅛"
1 of #71A
(a)
Pitch 6.77"
Repeat Basket Work.
5'-3"
6'-4"
¾"
1'-11⅛"
1 of #72
(c)
Pitch 10"×7.66"
7'-1⅜"
Repeat Basket Work
6'-0½"
¾"
1'-11⅝"
12 of #73
(d)
1 of #76
Pitch 10"×6.77"
(g)'
6'-0½"
4¾" L Frame
2'-10¾"
Pitch 10"×6.77" 7'-3⅝"
1 of #76A
(h)
6'-0½"
¾" L
7'-3⅝"
2'-10¾"
Pitch 10"×6.77"
1 of #78
5'-3"
¾" L
6'-4"
2'-10¾"
Pitch 10"×7.66"
12 of #77
(i)
(j)
6'-0½"
¾" L
7'-1⅜"
3'-0¾"
¾" L
Repeat Basket Work.
2'-6"
1 of #75
6'-0½"
(f)
Repeat Basket Work
2'-6"
¾" L
7 of #74
5'-3"
(g)
Risers.
3½"
6½"
25 of #32 2'-11¾"×6.77"
102 of #33 2'-11¾"×7.66"
(l)
Note: 7 Risers Cast on Facias.
3'-6½"
¾" L
6 of #79
5'-3"
¾" L
3'-6½"
1 of #80
6'-0½"
(k)
Facias
Cope over Flanges.
10½"
2"-3"
1'-9⅝"
Flange
2, 3, 4, 5, 6 and 7th Floor Starts
6 of #16
3'-5½"
(m)
¾" L
(l')
1 of #81
5'-3"
2 of #43 Pitch 10"×6.77"
1 of #44 7'-9½" Pitch 10"×6.77"
12 of #45 6'-10" Pitch 10"×7.66"
8'-1⅝"
(q)
#17
#18
1 of #17 2nd Floor Landing.
2'-11¾"
6 of #18 3rd to 8th Floor Landings.
2'-11¾"
(n)
(o)
7 of #46 5'-8"
1 of #47 6'-5½"
4"
6 of #63 Pitch 10"×6.77"
24 of #65 Pitch 10"×7.66"
(w)
Transom, Center Rail, and Base Rail Leaves.
9"
6 of #39 5'-8"
1 of #40 6'-5½" (p)
2 of #36 Pitch 10"×6.77"
1 of #37 7'-9½" Pitch 10"×6.77"
12 of #38 6'-10" Pitch 10"×7.66"
8'-1⅝"
(r)
Flange 3" High
3⅝"
5"
3⅝"
¾ Thick
5"
(z)
9"
3 of #57 Pitch 10"×6.77"
12 of #59 Pitch 10"×7.66"
(t)
9"
3 of #58 Pitch 10"×6.77"
12 of #59 Pitch 10"×7.66"
(u)
9"
7 of #62
(v)
9"
7 of #61
4"
16 of #68
(x)
Bases
7"
1 of #50 5'-8"
1 of #51 6'-5½"
(s)
Plates 4 of #106
7"
7"
2 of #54 2 of #53
(y)

FIG. 41



g
Section of Riser
1 1/2"
3"
2nd to Roof 7.66" and
1st to 2nd 6.77"
7/16"
Holes for 1/4" Bolts
Outside Line of Panel on back
h
7/8"
Face of Riser.
(b)
9"
f
e
4"
d
c
3/4"
(c)
Section of Arch taken through center
Arch to be Perforated.
Plaster
2"
12"
1 1/4" Marble Tread.
a
b
Section of Strings
(a)

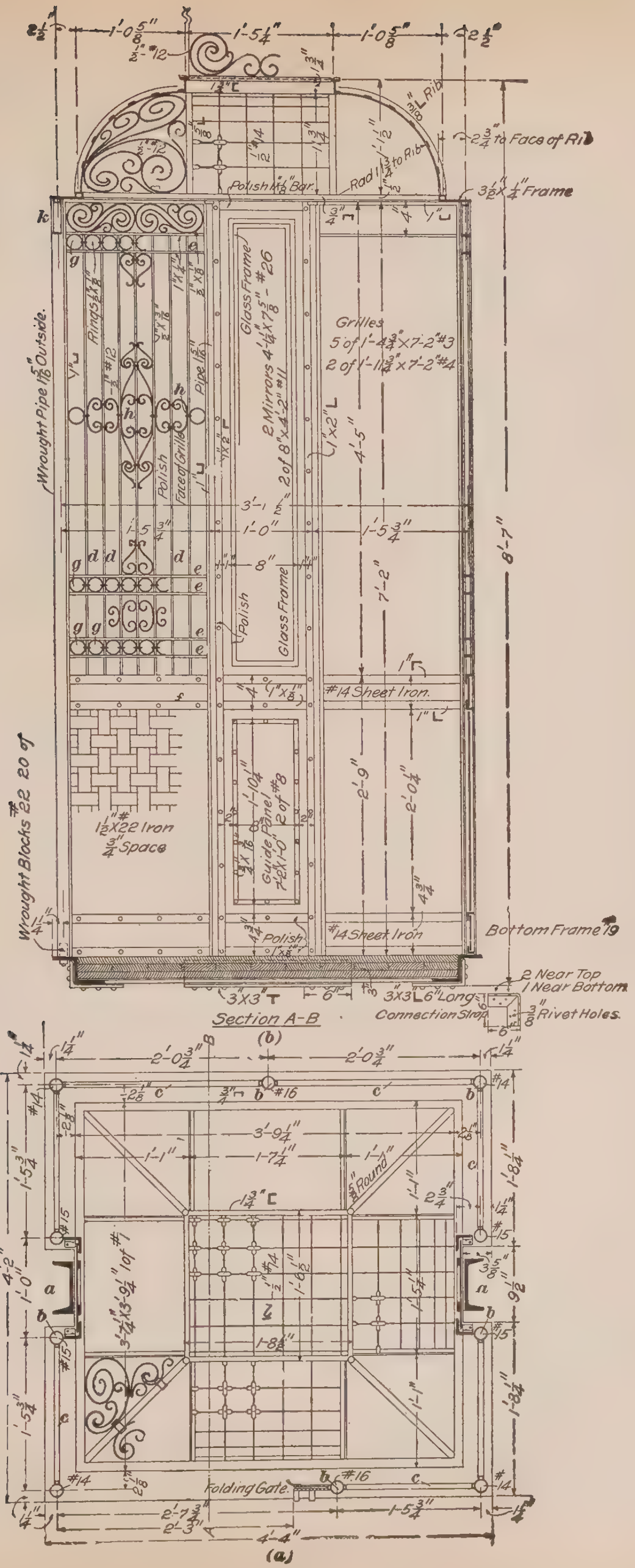
FIG. 42

21. The risers shown in Fig. 41 (*l*) are for all starters on each floor, and for all intermediate risers. The fascias or finish at back of risers underneath stairways shown in Fig. 41 (*m*) are at the start of the upper stories, and form a finish from the first tread (going up) to the plaster of the the ceiling below. See Fig. 39 (*d*). The seven risers cast on the fascias are shown at (*n*), and are for the upper landings, and form a finish from the last tread (going up) to the under side of the plaster. A number of the rails and bases are shown at (*o*), (*p*), (*q*), (*r*), and (*s*); the base (*s*) finishes the enclosure on the first floor only. The center rails (*o*) and (*p*) extend throughout all floors, as do the top rails (*q*) and (*r*). The leaves forming the finish, and covering the joints of the transom, center rail, and base rail, are shown at (*t*). See Fig. 39 (*d*). The finish at the base of the angle irons at the first floor is shown at (*y*) and (*z*), the latter being the plate that is bolted to the I beams to form the foundation of the enclosure, the four angles at the corner being bolted to these plates. The basket grille, which forms the dado of the enclosure, is shown at (*a*), (*b*), (*c*), (*d*), (*f*), and (*g*), and the grille-work at (*g*′), (*h*), (*i*), (*j*), (*k*), and (*l*′).

22. Fig. 42 (*a*) shows the strings, enclosure, arch, and riser in detail. The wall string is shown at *a*, and the well string at *b*; the frame of the basket grille composed of small angle irons is shown at *c*, and the center rail at *d*; the grille frame composed of small angles at *e*, and the top rail at *f*. A section of the riser and an elevation of the front of the same are shown at *g* and *h* in Fig. 42 (*b*); and the arch rib is shown in Fig. 42 (*c*).

ELEVATOR CARS

23. **Elevator cars** are usually constructed of angle iron or pipe framework, which is filled in with woven basketwork and twisted-iron grille-work and scrollwork. The design of the grille-work is usually similar to, if not identical with, the design of the grille of the enclosure, though sometimes certain conditions require a stronger and less elaborate design in one place than in the other.



Section A-B

(b)

(a)

FIG. 43

In Fig. 43 is shown a plan (*a*) and a section (taken on the line *A B*) or interior elevation (*b*) of the elevator car, the design of which is simple and inexpensive, while the construction is substantial and serviceable.

The plan (*a*) shows two recesses *a*, *a*, in which are located the guides, thus permitting the car to extend the full width of the shaft. The frame of the car is composed mostly of wrought-iron pipe, as shown at *b* in the plan, between the vertical members of which small channels *c* are secured to receive the basketwork and grilles. On the inside of the car the guides are covered with sheet-iron dado panels, extending 2 feet 9 inches above the floor and with a beveled plate-glass mirror from here to the top of the car. The rest of the side walls of the car, with the exception of the door, is composed entirely of grille-work.

24. The dado consists of a simple basketwork of 1½-inch iron straps, spaced ¾ inch apart and secured by riveting the end of each strap to the leg of a 1-inch angle iron, as shown at *f*, Fig. 43 (*b*). The space between the dado and the grillework consists of a sheet-iron panel secured in place by riveting it to the vertical legs of two 1-inch angle irons, which are framed in between the vertical supports.

The grilles forming the upper part of the elevator are composed of $\frac{1}{2}'' \times \frac{3}{16}''$ bars *d*, which are held vertically in place by means of $1'' \times \frac{1}{4}''$ horizontal rails *e*, through which the vertical members extend. By arranging the rails in pairs and keeping their distance apart equal to the spaces between the vertical members, a series of squares is formed, in which rings are inserted, as shown at *g*, thus bracing the joint and rendering the entire grille stiff and secure. Across the middle of the grille, a series of scroll ornaments *h* relieves the plainness of the panel, while at the same time it gives lateral stiffness to the vertical bars. At the top of the wall panels a scroll design *k* forms a frieze at the ceiling line, and it serves to combine the character of the side walls with that of the domed roof. The grilles of the roof are of simple twisted strap iron, such as described in Art. **5**, and scrollwork.

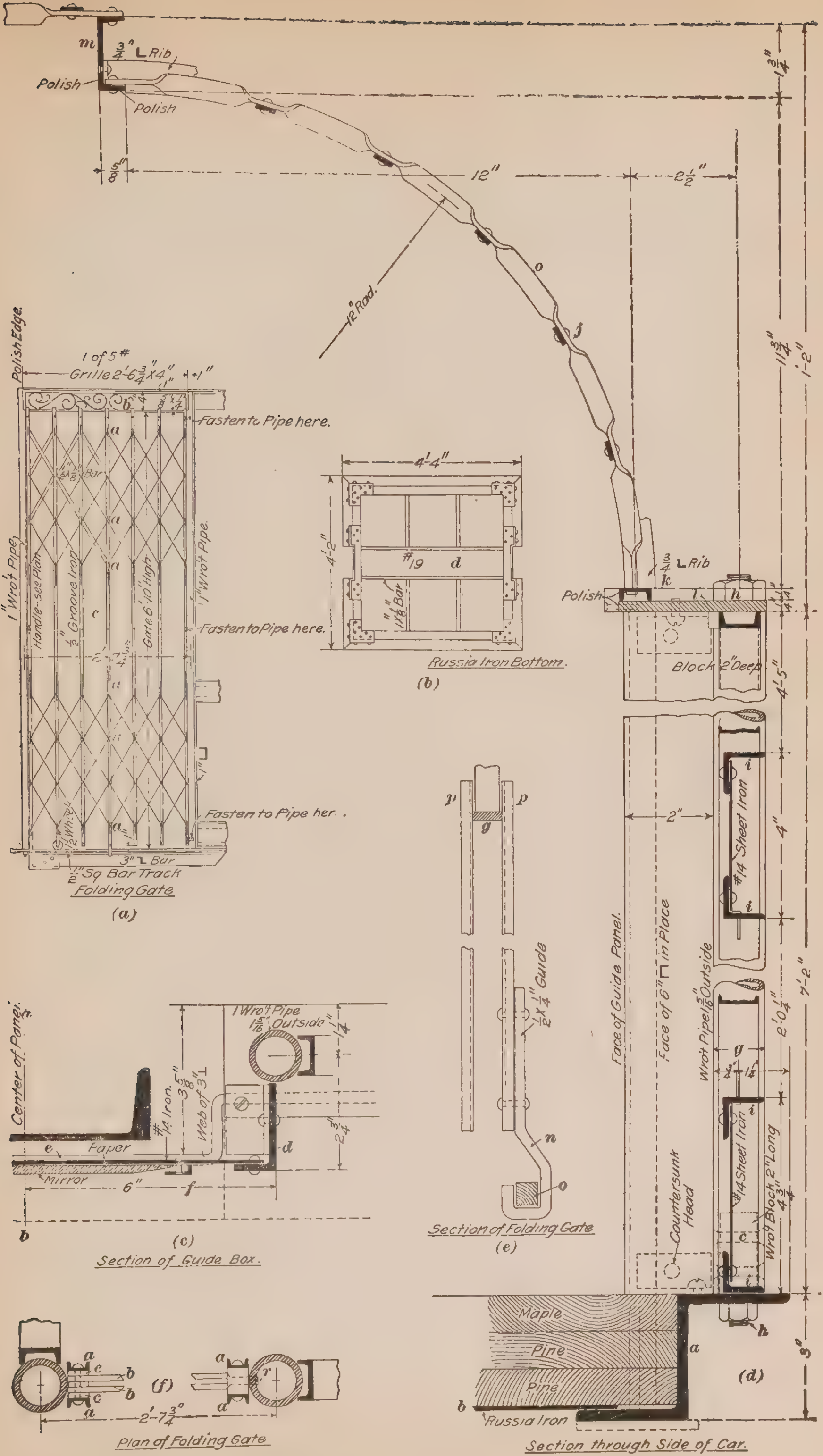

m
3/4" L Rib
Polish
Polish
5/8"
12"
2 1/2"
1 3/4"
12" Rad.
o
j
11 3/4"
1'-2"
Polish Edge.
1 of 5#
Grille 2'-6 3/4" x 4"
1"
1"
Fasten to Pipe here.
1 1/8" Bar
1" Wro't Pipe
Handle-see Plan
1/2" Groove Iron
Gate 6'-10" High
1" Wro't Pipe.
Fasten to Pipe here.
Fasten to Pipe her.
1/2" Wheel
3" L Bar
1/2" Sq Bar Track
Folding Gate
(a)
4'-4"
4'-2"
#19
d
1 x 1/8" Bar
Russia Iron Bottom.
(b)
3/4 L Rib
k
Polish
l
h
Block 2" Deep
4'-5"
p
p
g
1/2 x 1/4" Guide
n
o
Section of Folding Gate
(e)
Face of Guide Panel.
Face of 6" ⊓ in Place
2"
i
#14 Sheet Iron
4"
i
Wro't Pipe 1 5/16" Outside
2'-0 1/4"
7'-2"
g
1/4"
1/4"
i
#14 Sheet Iron
Wro't Block 2" Long
4 3/4"
c
i
Countersunk Head
Maple
Pine
Pine
a
b
Russia Iron
h
3"
(d)
Section through Side of Car.
Center of Panel.
1 Wro't Pipe
1 5/16" Outside
1/4"
3 5/8"
#14 Iron.
Web of 3" ⊥
2 3/4"
e
Paper
d
Mirror
6"
f
b
(c)
Section of Guide Box.
a
c
b
b
c
a
(f)
a
r
a
2'-7 3/4"
Plan of Folding Gate

FIG. 44

25. In Fig. 44 (*d*) is shown a section through the side of the car, illustrating on a larger scale the details of its construction. The rectangular floor frame is composed of 3-inch **Z** bars as shown at *a*, and three thicknesses of wood flooring, lined with a Russia-iron shield *b*, resting on the lower flange of the **Z** bar, while the walls of the car are secured to its upper flange. The corner and intermediate supports *g*, composed of $1\frac{5}{16}$-inch wrought-iron pipe, are secured to the upper flange of the **Z** bar *a* at the floor level, and to a $\frac{1}{4}$-inch wrought-iron plate *l* at the top. This is accomplished by plugging the ends of the pipes with wrought-iron blocks and riveting the blocks in place through the pipe, as shown dotted at *c*. The ends of the plugging blocks are then cut with a screw thread and the nuts *h* turned up on them, after their insertion through the flange and plate. Two 1-inch angle irons *i* form the upper and lower members of the frame for the base and middle rail, as shown, and a 1-inch channel, extending full length of the sides and across the top of each panel, fastens the grilles and scrolls in their places. A smaller channel *k* rests on top of the plate *l* and receives the lower ends of the vertical members of the roof grille *o*. At *m*, another channel set vertically receives the upper ends of the vertical members of the roof grille, and also the ends of the straps forming the center ceiling panel shown at *l*, Fig. 43 (*a*). The straps of the dome and ceiling grilles are $\frac{1}{2}'' \times \frac{3}{16}''$ iron twisted as shown, and are riveted where they cross at *j*, as described in Art. **5.**

26. In Fig. 44 (*c*) is shown a section through the panel and guide at the side of the car, the line *a b* being the center line through the guides. The angle irons *d* are fastened to the flange of the **Z** bar at the bottom and to the $\frac{1}{4}$-inch plate at the top by means of small angle-iron knees, and a plate of sheet iron *e* riveted to the short legs of the angles forms the back of the chase or guide recess. On the inside of the car a mirror is fastened to this plate by means of $\frac{5}{8}'' \times \frac{1}{4}''$ angle irons screwed to the back of the chase with countersunk screw bolts.

27. An elevation of the sliding or folding gate, protecting the entrance to the car, is shown in Fig. 44 (*a*), while Fig. 44 (*e*) shows a large scale detail of the bottom of the sliding post of the gate *n* and the guide *o* in which it slides. The vertical members of the gate are each composed of a pair of $\frac{1}{2}$-inch channels, as shown at *a* in Fig. 44 (*f*), which is

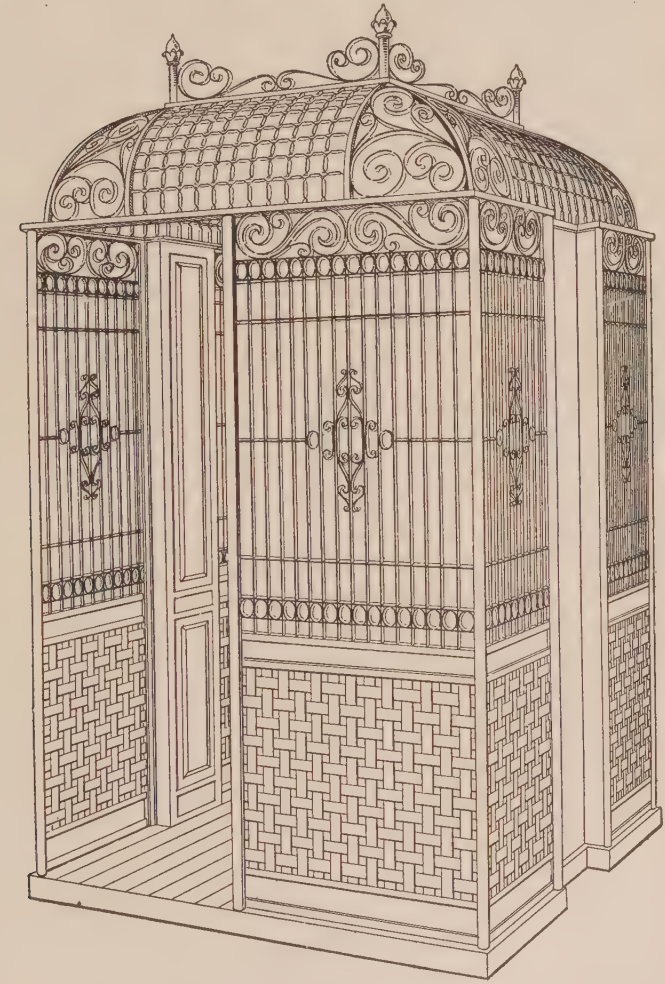


Fig. 45

an enlarged plan. Between these channels, the diagonal lattice bars *b* are secured as shown, with washers *c* between them to prevent their rubbing together as the gate is opened and shut. The rivets securing this latticework to the channels are not driven tight, but are left sufficiently free to play up and down in the slotted openings *a* shown in the elevation, Fig. 44 (*a*). Thus, the gate, which effectively bars the 2′ 7¾″ opening in the car, occupies only the width of the seven vertical channels, or 3½ inches when folded together so as to open the elevator. On the exterior channel, a ½″ × ¼″ guide is riveted, as shown at *n* in Fig. 44 (*e*), and on the under side of the **Z**-bar flange a track *o* is secured for the guide to travel in. At the top of the gate, the ½-inch channels are carried up each side of the frieze grille of the car, as shown at *b*, Fig. 44 (*a*), and also in Fig. 44 (*e*), where the lower bar of the frieze grille is shown at *g* and the side bars or channels at *p*. The general appearance of the completed car with all of its parts assembled, is illustrated in Fig. 45.

28. In Fig. 46 is shown a reproduction of a shop drawing of one of these cars, which was to be one of several all constructed alike, and accounts for the excess of material stated on the drawing for the different parts. This car is designed for a similar disposition of tracks and guides as the last example, but the design is more elaborate. The bottom of the car shown at *a* in the interior elevation (*a*) is of wood; the upright framing is of square tubes, as shown at *b* in the plan (*b*), inside of which an iron rod *c* passes through the floor and the cornice *d*, and secures these parts as shown in Fig. 46 (*a*). The framework is bound together horizontally by rods at the rail and base, as shown in the elevation (*d*) at *e*, and by the cornice at the top. Similar rods are placed in the corners behind the projecting panels on each side, thus binding the whole car together. The top of the car is of sheet iron, and, being dome-shaped, is self-supporting. The sides of the car are of cast iron below the rail, and cast and wrought iron above, with a mirror on each side. The small section of front adjoining the door shown in the plan (*b*) at *s*

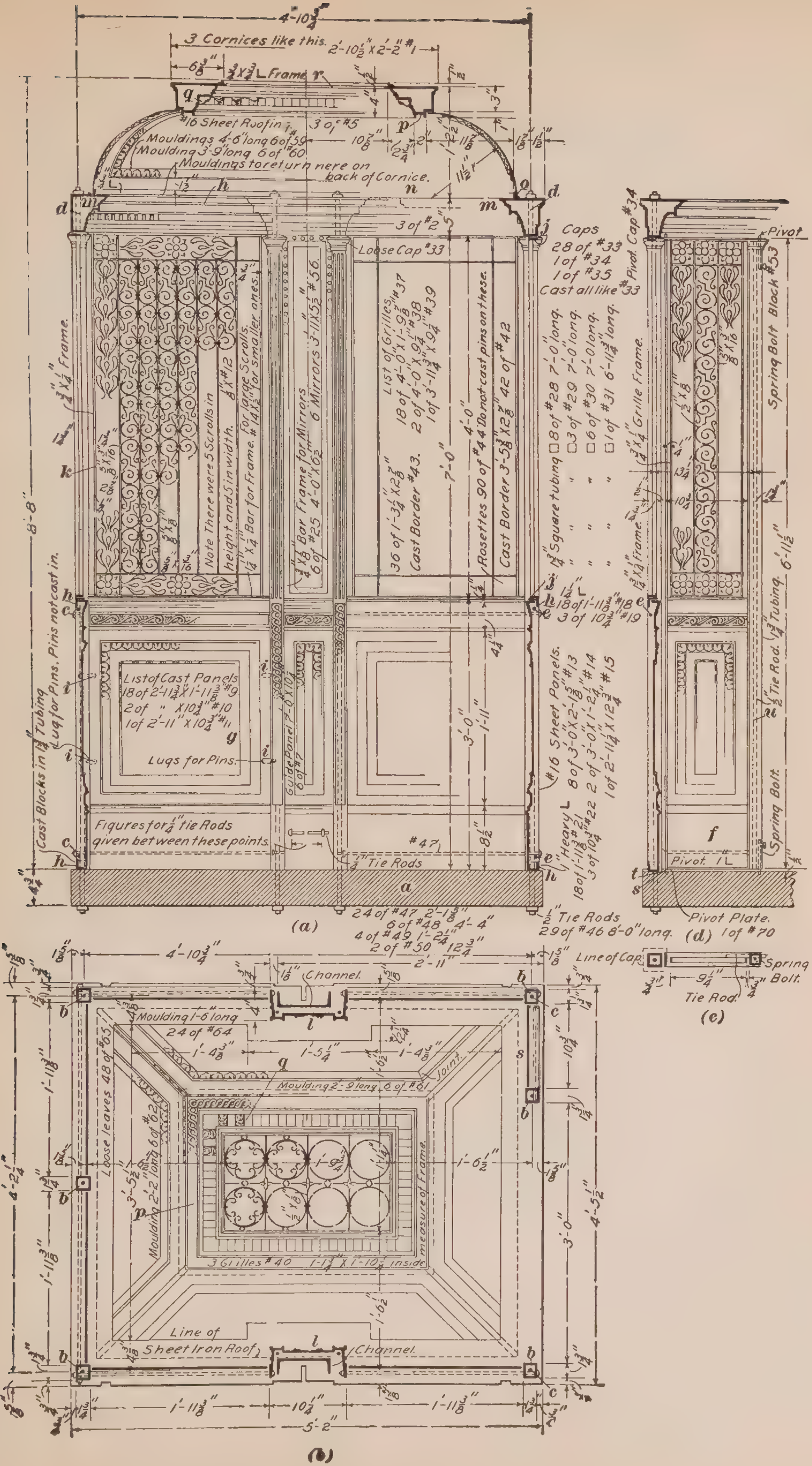

4'-10¾"
3 Cornices like this. 2'-10½" x 2'-2" #1
6⅜"
¾ x ¾ L Frame
#16 Sheet Roofing
3 of #5
Mouldings 4'-6" long 6 of #59
Moulding 3'-9" long 6 of #60
Mouldings to return here on back of Cornice.
3 of #2
Loose Cap #33
Caps
28 of #33
1 of #34
1 of #35
Cast all like #33
Pivot Cap #34
Pivot
Spring Bolt Block #53
¾ x ¼" Frame.
Note There were 5 Scrolls in height and 5 in width.
For large Scrolls. 1¼ x ¼" Bar for Frame. #14 x ⅛ for smaller ones.
¼ x 8" Bar Frame for Mirrors 6 of #25 4'-0" x 6½"
6 Mirrors 3'-11" x 5½" #56
List of Grilles. 18 of 4'-0" x 1'-9⅞" #37
2 of 4'-0" x 9¼" #38
1 of 3'-11¼" x 9¼" #39
36 of 1'-3¼" x 2⅞" Cast Border #43.
Rosettes 90 of #44 Do not cast pins on these.
Cast Border 3'-5⅜" x 2⅞" 42 of #42
□ 8 of #28 7'-0" long.
□ 3 of #29 7'-0" long.
□ 6 of #30 7'-0" long.
□ 1 of #31 6'-11¾" long.
¾" Square tubing
¾ x ¼" Grille Frame.
1¼ x ¼" Frame.
1¼" L
18 of 1'-11⅜" #18
3 of 10¾" #19
Cast Blocks in 1¼" Tubing Lug for Pins. Pins not cast in.
List of Cast Panels
18 of 2'-11¾" x 1'-11⅜" #9
2 of " x 10¾" #10
1 of 2'-11" x 10¾" #11
Lugs for Pins.
Guide Panel 7'-0" x 10¼" 6 of #7
Figures for ¼" tie Rods given between these points.
¼" Tie Rods
#47
#16 Sheet Panels.
8 of 3'-0" x 2'-1⅜" #13
2 of 3'-0" x 1'-2¼" #14
1 of 2'-11¼" x 12¾" #15
1" Heavy L
18 of 1'-11⅜" #21
3 of 10¾" #22
24 of #47 2'-1⅜"
6 of #48 4'-4"
4 of #49 1'-2¼"
2 of #50 12¾"
½" Tie Rods
29 of #46 8'-0" long.
8'-8"
7'-0"
4'-0"
3'-0"
1'-11"
6'-11½"
1¾" Tubing.
½" Tie Rod.
Spring Bolt.
Pivot. 1 L
Pivot Plate. 1 of #70
(a)
(d)
1⅝"
4'-10¾"
2'-11"
⅛" Channel.
Moulding 1'-6" long 24 of #64
1'-4⅜"
1'-5¼"
Joint.
Moulding 2'-9" long 6 of #61
Loose leaves 48 of #63
Moulding 2'-2" long 6 of #62
measure of Frame.
3 Grilles #40 1'-1¾" x 1'-10¼" inside
Line of Sheet Iron Roof
Channel.
1'-6½"
3'-0"
4'-5½"
4'-2¼"
1'-11⅜"
10¼"
5'-2"
Line of Cap
Spring Bolt.
9¼"
Tie Rod.
(c)
(b)
a b c d e f g h i j k l m n o p q r s t u

FIG. 46

is made to swing inwards, to allow the use of the full width of the car in handling merchandise. The outside of the car below the rail is covered with sheet iron. The dado of the side shown at *g* in the elevation (*a*) is cast in one piece, including the base, panel, frieze, and cap. The base and cap are plain molded; the outside molding of the panel is decorated with a link leaf and the inner with a spool-and-reed ornament. The casting is fastened at the top and bottom by bolts through the angle irons *h*, which are framed in between, and bolted to, each pair of corner posts. At the sides, the panels are held by small lugs cast on them to receive dowel-pins, as shown at *i*, elevation (*a*). The top and bottom of the outside frames for the grilles shown at *j*, elevation (*a*), are made of $1\frac{1}{4}'' \times \frac{1}{4}''$ bar iron, and the sides *k* of $\frac{3}{4}'' \times \frac{1}{4}''$ iron. The inside frame dividing the cast-iron border and the grille is of $\frac{5}{8}'' \times \frac{3}{16}''$ iron, as shown; the bars of the grille are $\frac{5}{8}$ in. × $\frac{1}{8}$ in., and the scrolls are all $\frac{1}{8}$ inch thick. The cast-iron border of the grille is a laurel-leaf design with a rosette in each corner and in the center of the top and bottom sections. The scrolls are fastened to the frame by rivets; but to the bars, they are held by straps. The cast-iron guide box, shown at *l* in the plan (*b*), is strengthened at the corners and finished on the inside with a pilaster, the upper part or shaft of which is fluted and finished with a cap, while the pedestal is paneled and filled with a guilloche ornament. The cornice is of cast iron, molded and ornamented with a dentil course, as shown on the interior elevation, while on the back it is finished with small moldings top and bottom, which return as indicated by the dotted lines *n*. The dome plates are mitered at the angles and paneled on the inside face. The miters are covered with bronze spool-and-reed moldings, and the panel molding is decorated with a leaf link. The dome plates are secured to the vertical leg of an angle *o*, which is riveted to the top of the cornice of the car; and the cast-iron cornice of the dome is supported by these dome plates. The soffit of this dome cornice is decorated with a guilloche, as shown at *p* in the plan, while its fascia and corona are supported on modillion brackets, as

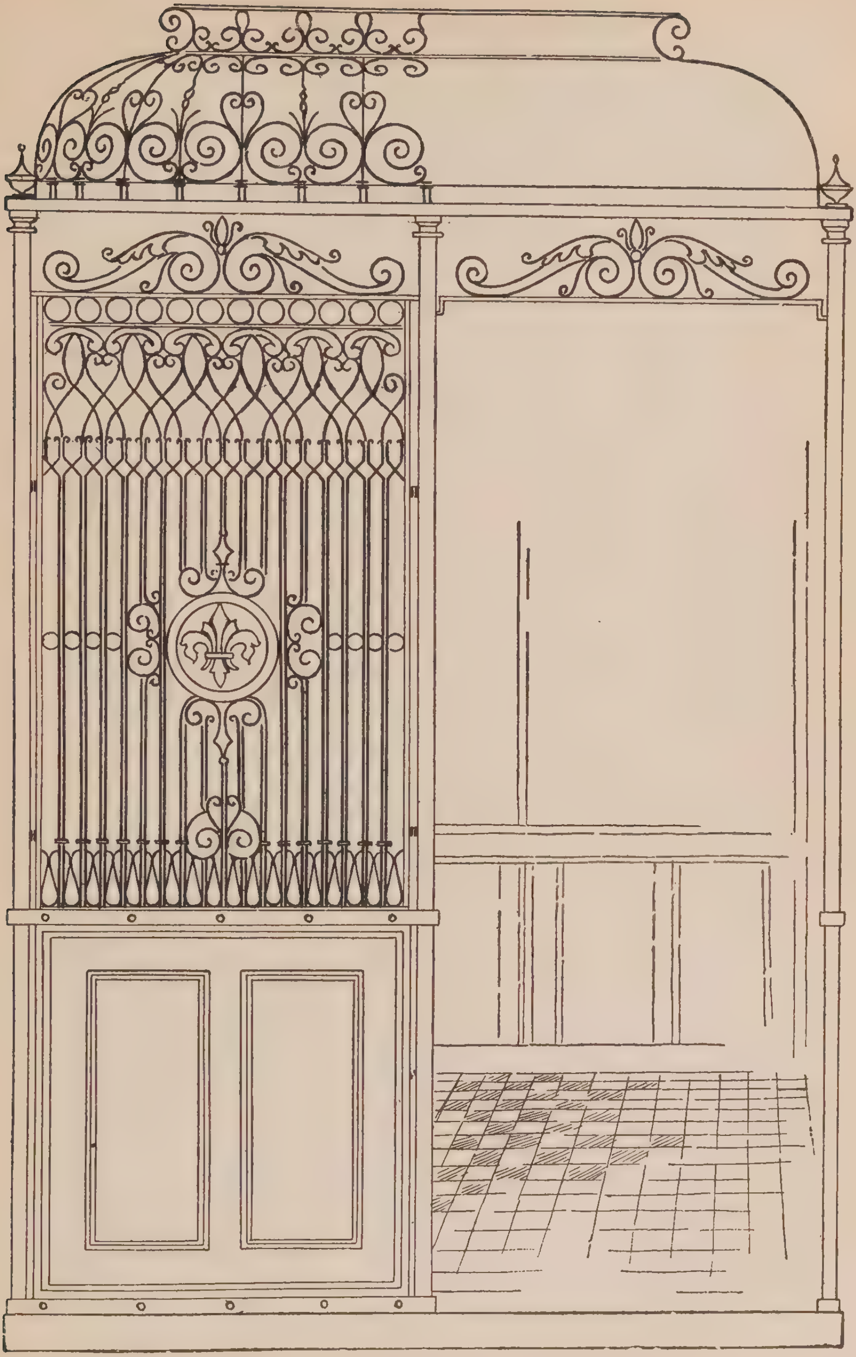


FIG. 47

shown at *q*. The dome grille *r*, elevation (*a*), is designed suggestive of the usual treatment of a ceiling, being first divided into panels, which are afterwards filled with a circle, and the circle with a quarterfoil of scrolls. This grille is set in an angle-iron frame, which is bolted to the cornice. The swinging door shown in the plan at *s* is seen in elevation at (*d*). The pivots *s* are riveted to the frame of the grille, the top one being inserted in the cornice and the bottom one in the pivot plate *t*. The top and bottom of the post *u* are fitted with spring bolts, which are withdrawn when the section is to be opened.

By a careful inspection of the details of the preceding examples, the construction of elevator cars should now be fully comprehended; and, as such work does not differ materially, there should be no difficulty in designing the construction details of any car required.

29. In Fig. 47 is shown a design for an elevator car entirely of wrought iron. The grille differs from the previous examples, as it has no border, but is divided into a dado, field, and frieze. The dado is composed of a series of oval scrolls, the field has a cartouch with a fleur-de-lis in the center, and the frieze is an interwoven pattern, surmounted by a series of rings. The panels that take the place of the cornice are filled with scrolls and decorated with leaves having a flower or bud at the center. The grille of the dome is in motive similar to the honeysuckle decoration used in classic architecture.

The car illustrated in Fig. 48 is of wrought iron, and the dado is a diaper of basketwork. The grille, by the arrangement of the scrolls, does away with a border top and bottom, but, as it is divided into three panels having the bars gathered reed fashion, it is necessary that a border be provided to close the space at the sides. The rods forming the reeds are separated by button washers and are riveted together. The dome of this car is circular in plan, and is divided into a series of radiating panels that finish at the bottom with a link-scroll design and at the top with rings. The crown of the dome has the scrolls so arranged that they form a natural continuation of the panels.

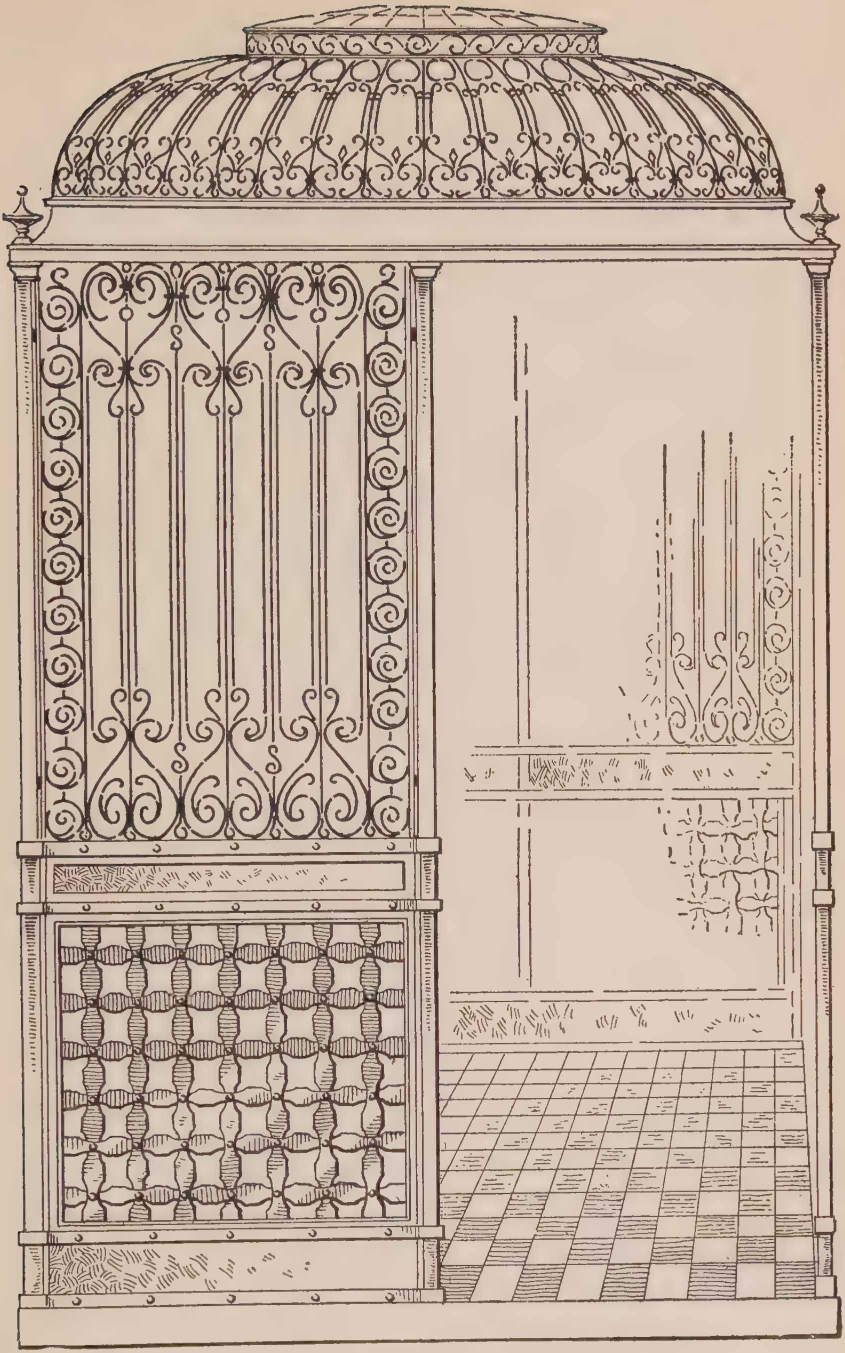


FIG. 45

LEAVES AND FOLIATED WORK

30. All the work considered up to the present time has been purely structural. Such ornament as has been necessary in elevator fronts or office partitions has been of a conventional character, and is confined to strap-iron grilles. Now, however, another kind of ornamental ironwork will be considered, namely, the execution of leaves and flowers in sheet and bar iron, by means of forging and working the metal. No machinery is required for this work, and to produce satisfactory results, a knowledge of designs, methods, and tools in use are indispensable.

In this branch of wrought-iron work, the designer should be intimately acquainted with his material; he should know how much working his metal will stand under certain conditions, and how much working his design will require to bring it into shape. He should know at what point and under what conditions forging will be necessary, how much of the work can be formed cold, and what details will have to be executed with the metal at a red or a white heat. Wrought-iron leaves are usually executed in sheet metal and hammered into shape; flowers sometimes require both sheet and bar metal; while designs of foliated grille-work require sheet, bar, and strap iron in varying quantities, according to the character of the work.

31. In Fig. 49 is shown a finished leaf as it would appear when permanently placed in position. To reproduce this leaf in iron, it will first be necessary to make a developed drawing of it—that is, a drawing of the leaf as it would appear if flattened out to the original shape of the metal when first cut out, before working in any manner. It is hardly possible to lay it out exactly—and in fact, such accuracy is not required, for, if the general dimensions are correct, the other parts may be worked into shape in subsequent

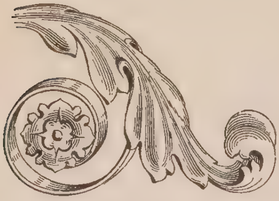


FIG. 49

operations. In Fig. 50 is shown the general appearance of the developed drawing. This drawing should now be carefully traced on the sheet metal and cut out. The crude iron leaf is then placed on a block of soft metal, such as lead, and cold-hammered into the general shape required. As constant hammering is likely to make the metal brittle and hard, it is sometimes necessary to anneal the iron in the forge several times before the leaf is finished. Special forms of hammers are used to shape the work. Two of these hammers are shown in Fig. 51. The one at (*a*) is flat on both faces, and is used in the general shaping of the leaf; while the one at (*b*), which has a spherical head, is used to produce the curves of the lobes and indentations, and to bring the leaf to its finished form. The flared face opposite the spherical head is brought into service when sharp indentations or veins are to be formed, though for this purpose other tools and punches are also used in connection with the work.

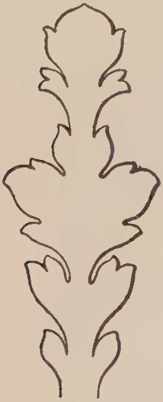


Fig. 50

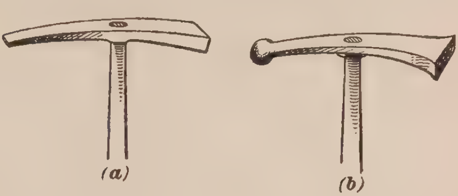


Fig. 51

32. In designing leafwork for a grille, a gate, or a railing, consideration should always be given to the appropriateness of its position in accordance with the utility of the device and the architectural style of the building. For instance, in the elevator cars and enclosures heretofore discussed, little or no consideration has been given to wrought-iron leafwork, because an elevator is essentially a utilitarian device, and such ornamental features as are expressed in its design should be a part and detail of the necessities of its construction. The grilled sides of the elevator are rendered ornamental by simply twisting the iron straps and bars of the frame filling into geometrical forms; but where a grille is inserted in a transom light, or over a gateway, merely as a finish and ornament to the opening, the design may be elaborated with leafwork, as the purpose of the grille is not utilitarian but ornamental. Again, the heavy gates of a carriage entranceway require some leaf decoration to harmonize with the design of their surroundings, but they should at the same time preserve their identity as a purely utilitarian detail. The leaves and tendrils should not be delicately modeled in thin metal, but should be boldly hammered from sheet iron of from $\frac{3}{32}$ to $\frac{5}{32}$ inch in thickness. There should be no feeling of frailty in such a detail, and the ornament should be as strong and serviceable as the main structural details of the gate.

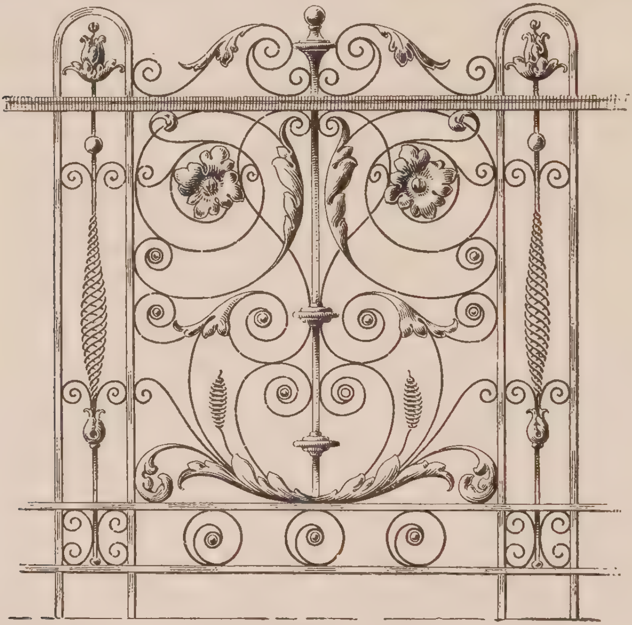


FIG. 52

33. In Fig. 52 is shown the design of a panel suitable for a light railing, or a protecting grille in front of a glass screen.

The lines of the design are too delicate to permit of its use in a position where it would receive hard usage, and its details may therefore be of very light materials. The main framework, it will be observed, is composed of substantial bar iron, while the filling and leafwork is of very light gauge. The treatment of the panel shown in Fig. 53 is the reverse of this. Heavy framework filled in with substantially proportioned scrolls and bars forms the general scheme of the design, while the leafwork is applied to the parts where the scrolls unite, and thereby renders the points of forging more pleasing to the eye. The leafwork in this design plays no part in the structural strength, but renders

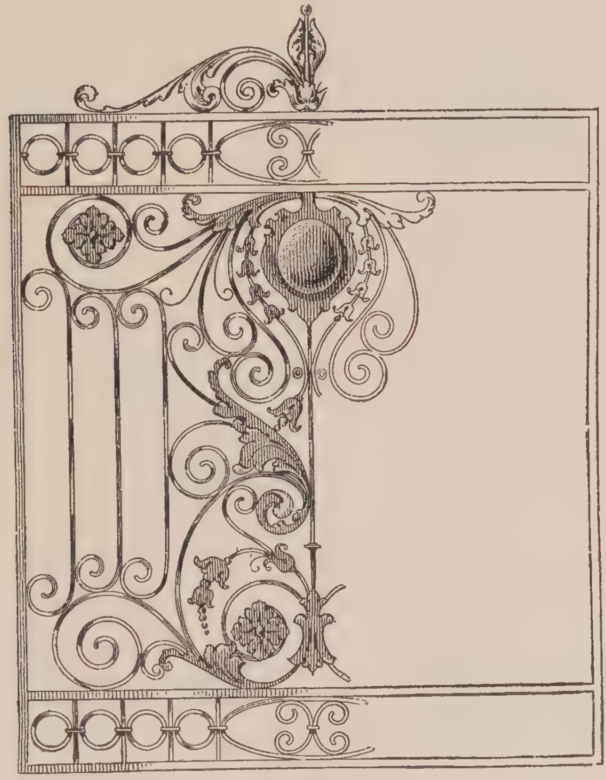


FIG. 53

the structural necessities artistic, by combining and uniting them under an artistic form.

These two examples, Figs. 52 and 53, are intended to show the two principal conditions to be met with in leafwork design. Fig. 52 shows a framework full of ornament, possessing little strength and mainly serving an ornamental purpose, while Fig. 53 shows a strong frame and rigid grille-work, certain details of which are emphasized with leaf design. In Fig. 53, strength is the main consideration, and the ornament clothes the utilitarian details in artistic forms.

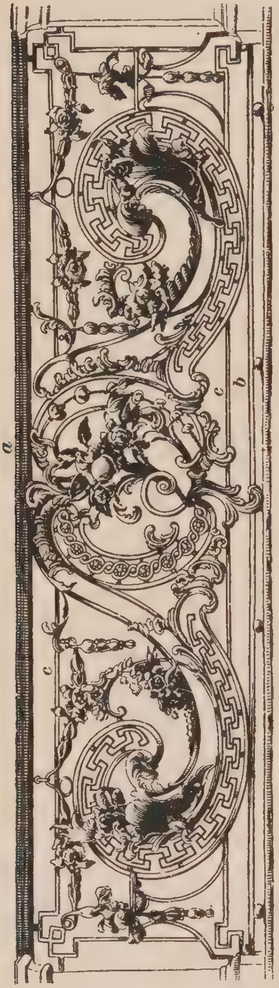


Fig. 54

34. In Fig. 54 is shown a piece of wrought-iron work that exceeds, in elaboration of design, anything heretofore considered. It is a design for one panel of a railing, placed in front of a window in a modern flat building, and is intended to be supported at each end by a heavy stone pier or pilaster. The top rail *a* and the bottom rail *b* extend from one of these posts to the other in an unbroken line, while the inner rail *c* is broken by the lines of the main scrolls, and is worked into a fret design in the corners. As the filling of this panel is nearly all leafwork, it follows that the leaves should be wrought in a heavy gauge of iron. The delicacy of the design will in no way be impaired by such treatment, as the parts should possess an appearance of strength sufficient to fulfil their several functions.

The main lines of the ornament in this design are composed of heavy iron bars, to which the leafwork is secured by forging. The double lines of the large scrolls forming the scheme of design at each end are filled in with a fret ornament of light iron. The iron of the main scroll being wider than that of the fret, the latter is protected from injury, but is raised from its support on button washers, in order that it may be more readily seen. The same may be said of the guilloche ornament on the left side of the center scroll, but the stem-and-bud ornament on the right side of the centerpiece is bent in place independent of the surrounding bars.

The leafwork is forged to the structural details as shown, and therefore seems to form a natural part of them, though the style of leaf is of a debased system of design. The example, however, serves to illustrate the extremes to which wrought-iron-work designs may be carried, and the tasks that a skilful workman may be called on to carry out.

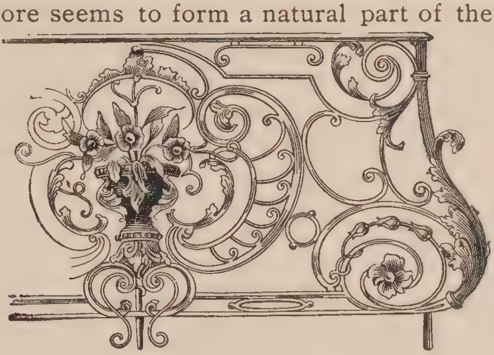


FIG. 55

Fig. 55 shows another design that, though less ornate in its leafwork, is equally complex in the arrangement and management of its scrolls. The main scroll lines break and change their direction suddenly, thereby leaving some points improperly secured, and necessitating other scrolls to hold them in place. The centerpiece is executed entirely in sheet metal, the drooping leaves being fastened to the surface of the vase with rivets. The main leaf of the scroll on the right-hand end of the rail is somewhat similar to the one shown in

Fig. 49, though larger. In this position, it forms an ornate finish to the panel, and at the same time serves as a floral calyx out of which the lower lines of the scroll appear to naturally grow.

FORGED WORK

35. In the succeeding pages, descriptions of the illustrations given cannot be more than general, as the principal object is to give examples that are standards of artistic and ornamental design. Instruction in smithwork has not been attempted, nor has it been deemed advisable to try to cover the complete field of useful and ornamental objects made in wrought iron, but to discuss only a small number of the ones more commonly seen and used in house building.

That a knowledge of the tools and the methods employed in working iron may be made known, and that the designs shown may thereby be better understood, the following short description is given: The few primary tools consist of a forge, an anvil, a pair of tongs, an ordinary blacksmith's hammer, a fuller, a set of punches (say three sizes each of square and round), three swage hammers, a set hammer, a flatter, and a riveting hammer. The fuller and the swage hammers are usually called *top swages*, as a duplicate of the hammer face, which fits in a hole in the top of the anvil, is called a *bottom fuller*, or *swage*.

The making of grilles and scrolls by bending and riveting is described under another head. Any two or more parts joined while hot are called *welded*, and all objects worked from a single piece are called *forged*. Whether welded or forged, the iron should first be brought to a white heat, and work commenced with the metal at this color, and continued until the iron assumes a deep cherry red, although, of course, this will depend somewhat on the grade of iron used. When the object to be welded or wrought is placed on the anvil, the blows at first should be light, and gradually increased in force as the metal cools, the forging would only be needlessly changed in shape by hammering not graduated in this way. This point may be appreciated by watching a good blacksmith at work.

To convert a section of a flat bar into a round one, the bar is brought to the proper heat in the forge fire and then laid across a bottom fuller set in the anvil, where, with a pair of tongs, it is held edge up, with the fuller hammer on the upper side. In this position it is indented until the approximate size of the round is made. The bar will now look as though it had a nick cut out of it on each side, the space between being the guide for the round part. The bar is again heated, and a bottom swage put in the hole in the top of the anvil, and the bar is placed on the anvil and worked to a rough round. It is then once more heated, and this time placed in the bottom swage, the smith holding the top swage in place while the helper strikes the top of it repeatedly as the bar is drawn between the swages, producing an even, smooth finish.

In the case of a fence railing or window guard, where the bars or pickets are to pass through the horizontal rails, and it is desired that the rails shall be of a uniform section where bars pass through, it is necessary that the rail shall be what is termed *upset*, that is, heated and driven together endwise to produce a bulge at the desired portion; or a small piece may be welded on at the point where each bar is to pass through to compensate for the metal punched out; the rail is then heated, and the required hole is made with a square or a round punch. After reheating, the rail is passed over the anvil and finished with the flatter to remove all the marks of the other tools.

If two bars are to be joined at right angles, they are placed one over the other at a white heat and welded together with a common smith's hammer, after which the slight bulging at the juncture is worked out. In especially fine work, a small piece is cut from each bar at the point of welding, though this is seldom necessary in ordinary practice.

Surface cuts, indentations, etc., for the production of diaper designs or patterns on plain surfaces, should be made at a low heat with fullers set in the bench, or anvil, as the case may require, a guide or spacer being so placed as to keep the work uniform and true. The finials of posts and knobs on fence bars are first roughly forged out by hand, and then placed in a die under a trip hammer; or, where this is not at hand, the die is struck with sledges. When small work is welded, the tool marks are removed by the set hammer, which is simply a small flatter.

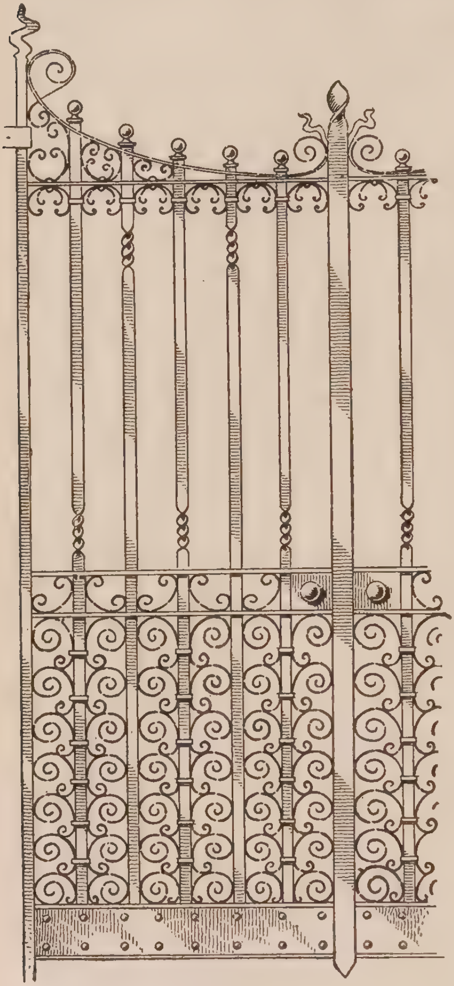


FIG. 56

36. In making festoons of leaves or flowers, or of both, a stem should first be made of the required length, and the pieces for the leaves cut from thin bar or strap iron, on which the individual stems of the flowers are welded. The shape of the leaf or flower is then worked out on a soft-metal block, as described for leafwork. When all the leaves and flowers are made, the main stem and a single leaf or flower are heated in the forge and welded together, this process being repeated with each leaf and flower until all are in place; they are then finished up and put in exact position or alinement after the metal is cold. When an object is to be forged out of a single piece of material, it is heated in the forge and worked under the hammer to the required shape or form; this is the most expensive part of wrought-iron work.

GATES AND FENCES

37. Most of the examples heretofore given have been of light work that could be made without heating the iron, but in Fig. 56 is shown ironwork of a more substantial character. The main bars are $1\frac{1}{2}$ inches square; the cross-bars are 3 in. × $1\frac{1}{2}$ in., wide enough for the uprights to pass through; and the scrollwork is of material $\frac{1}{4}$ in. × 1 in. When a bar is to be punched out, as in the horizontal members in this case, there should be ample metal left on each side of the hole punched to prevent the sides from spreading under the pressure of the punch and leaving the bar somewhat protruded at these points. The scrolls are alike in the lower part of the gate, and are fastened to the upright bars by a narrow strap on one side and a countersunk screw on the other. The hinge or hanger should be arranged at the top and made as shown in Fig. 57. The frame of the gate, which is a square bar, is rounded where the hinge clasps it, as shown at (*a*). The jagged part of the hinge is embedded in the stone piers or wall to which the gate is to be hung, and fixed in place with molten lead; or, where circumstances will permit, the bar is passed entirely through the wall and fastened on the other side with a large washer and nut. The gate is held by the clasp, which is secured with two bolts passing through the hinge bar, as shown at (*b*).

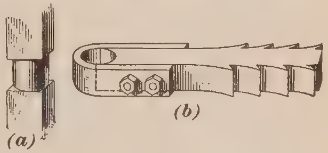


FIG. 57

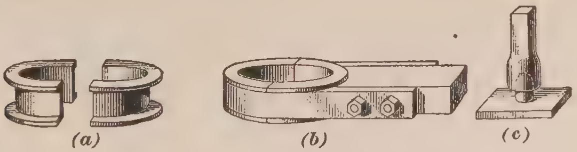


FIG. 58

In exceptionally high-grade work, the inside of the hinge is lined with a brass collar, as shown in Fig. 58 (*a*) and (*b*), which prevents the two surfaces from rusting when they are in contact. Nearly all gates, and especially heavy gates, are pivoted at the bottom; and the pivot is usually formed at the lower part, or *heel*, of the gate itself, and fits in a socket under the gate. The objection to this method is that the socket is likely to fill with dirt and make it difficult to move the gate. A better way is to make the socket a part of the gate, and have the pivot separate, as shown in Fig. 58 (*c*). An oil hole may then be bored through the socket in an oblique direction to the pivot, which may then be oiled; and, as the socket is in the gate, the dust and dirt cannot get in and clog it up.

38. The railing shown in Fig. 59 is a good example of forged work, and illustrates the application of leafwork without detracting from the lines of the fence. The main uprights and the horizontal rails are clearly defined, and, as they should be, are much heavier than the bars and scrolls filling the panels formed by them. The fence is divided into large panels or sections, one of them being a double gateway. The first two upright bars at the end of the panels are carried up, forming posts. An increase in the size of these bars would be an improvement and further emphasize the post effect. The top of the post is finished with a finial ornament, and the gate as well as the side panels are finished with a cresting. The cresting of the gates is arranged to group them as one panel, and the main scrolls are decorated with leafwork. The top and bottom of both the gates and panels are well braced with an open rail having a scroll let in between. The scrolls filling the top and bottom of the panels are finished with a leaf-and-bud ornament, and the bars are braced by three rows of rings secured with straps and screws. The posts from which the gates are hung are braced with triangular foot-braces, and these as well as the posts themselves are leaded into the stonework.

The gate shown in Fig. 60 is a vigorous, well-balanced design, decidedly foreign in character, and including in the design of its transom a conventionalized eagle. The side panels of the screen, as well as the outside of the transom, are open and less elaborate than the central panels, the contrast between them heightening the effect by separating the rich carving that existed on the stone architrave from the elaborate iron grille of the center. The transom bar is in four panels, each of which is filled between the border frame and lower rail with grille-work composed of crossed scrolls and decorated with leaves and rosettes. The continuation of the principal vertical lines from the screen to the transom bar is accomplished by a console bracket, the top of which clasps the transom-bar rail. A point in this design that might be improved is the manner in which the inner frame of the semicircular transom border is carried down past the

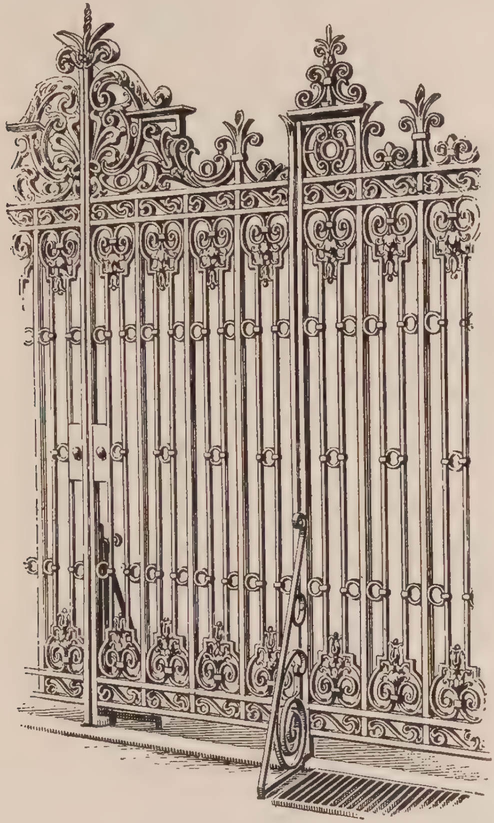


FIG. 59

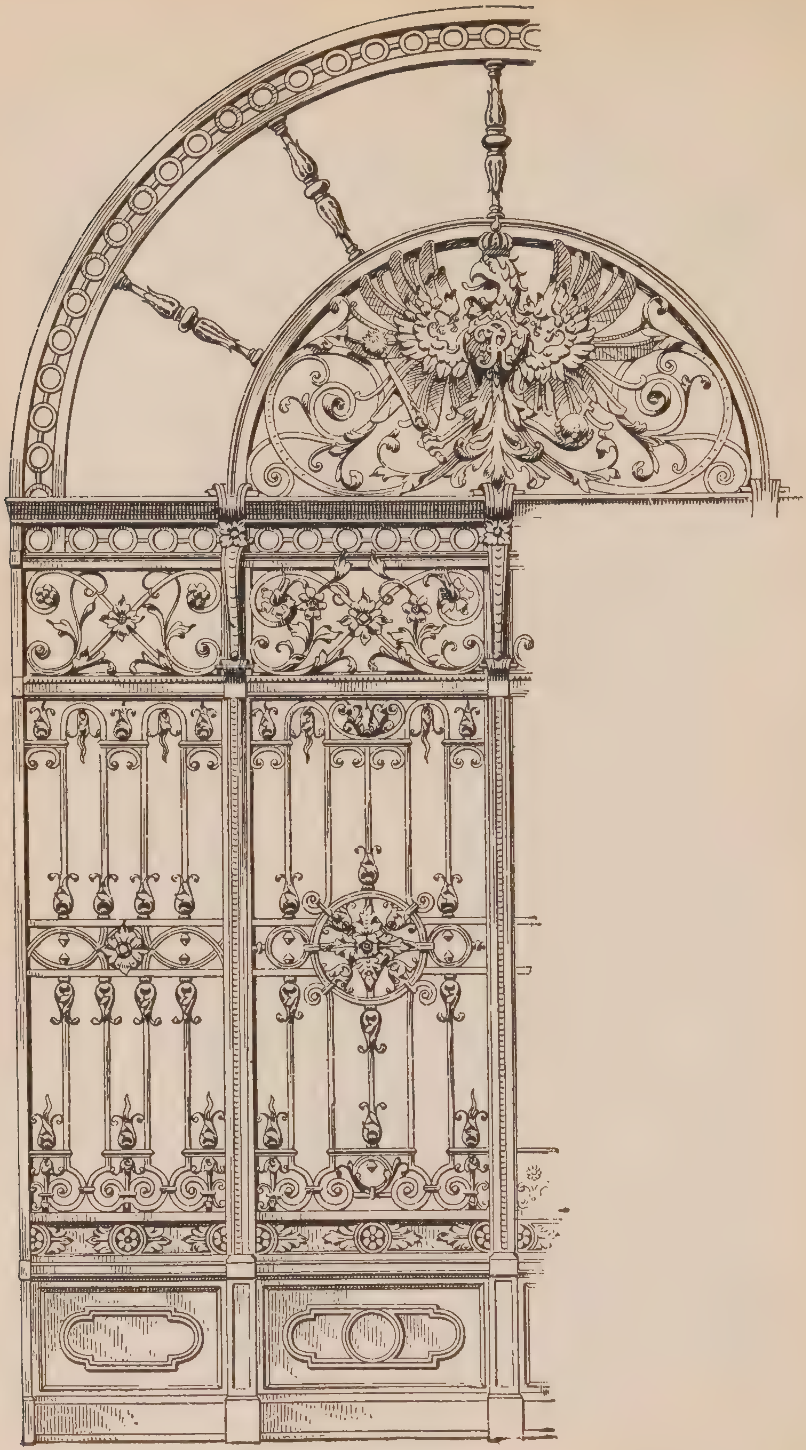


Fig. 60

top of the transom bar to the border frame, thus giving the idea that the transom frame is supported there; the omission of this piece of frame would considerably heighten the border effect and remove this weak appearance.

39. In Fig. 61 is an example of a small garden gate in cast iron, and, with the exception of the central shield and the ornament at the top, all the members are kept approximately the same general thickness, to avoid any danger of cracking during the cooling stage. The parts that appear heavier on the face are thinned out to preserve the balance of metal. Cast iron for small work of this kind is inferior to wrought iron, as the effect of contrasting heavy and delicate

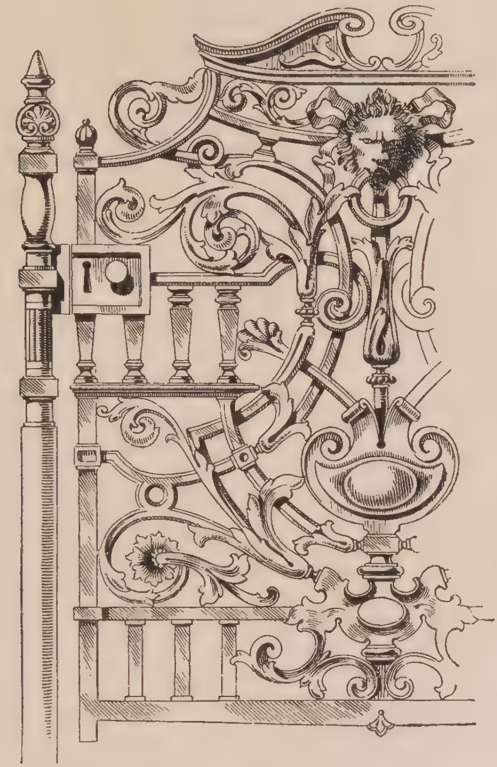


Fig. 61

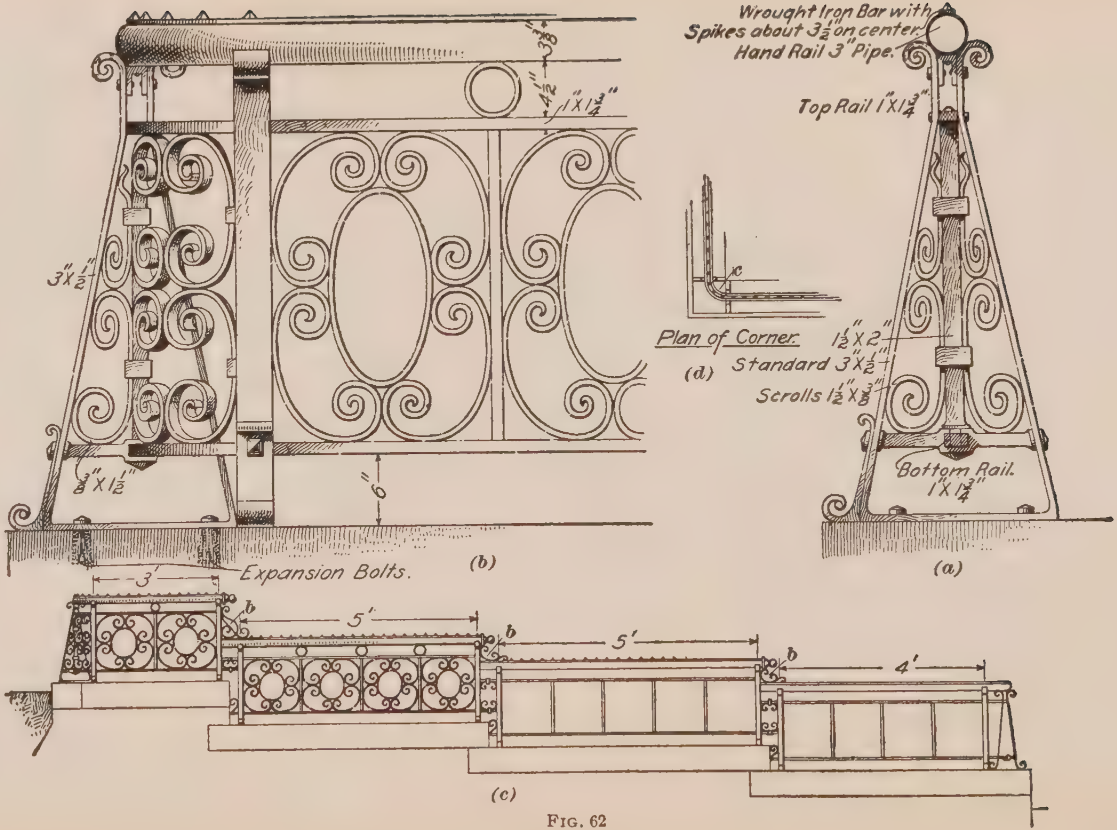

Wrought Iron Bar with Spikes about 3½" on center.
Hand Rail 3" Pipe.
Top Rail 1"X1¾"
1½"X2"
Standard 3"X½"
Scrolls 1½"X⅜"
Bottom Rail. 1"X1¾"
(a)
3⅜"
4½"
1"X1¾"
3"X½"
⅜"X1½"
6"
Expansion Bolts.
(b)
c
Plan of Corner.
(d)
3'
b
5'
b
5'
b
4'
(c)

FIG. 62

features is necessarily somewhat wanting, owing to the limitations of the material.

The railing shown in Fig. 62 is a very massive and well proportioned one. The posts, or supports, are made triangular in shape, as shown at (*a*), and would almost retain their position without the aid of the expansion bolts by which they are secured to the coping, as shown at (*b*). This railing tops a stepped coping, as shown at (*c*), and is joined by easy and graceful scrolls at the point of the step *b*. The corners are arranged as at *c* in the plan (*d*), and the grille is bent to the radius formed by the intersection of the supports at their bases. The hand rail is a wrought-iron pipe finished at the ends with a knob ornament, and the top has a bar studded with spikes to prevent lounging.

WINDOW GUARDS

40. **A window guard** should be primarily a protective device, and secondarily an ornament or decoration. As a rule, especially in private-residence work, the design of these very necessary features is not given a proper amount of attention, but they are certainly as deserving of careful consideration as any other ironwork of the structure. They may be made to form the divisions of the window opening in place of the bars of the sash, and to produce the desired effect of window subdivision, at the same time leaving the glass in any required size. It is not necessary that a window guard shall be flat, nor set between the jambs of the window opening; it may be a roomy addition to the window sill, fastened to the walls on either side of the jambs, wherein summer flowers may be placed to blossom in the sun and receive protection from high winds or careless hands. Small openings for ventilation or light may be rendered pleasing by simple and effective guards, such as those shown in Fig. 63 (*a*), (*b*), and (*c*), cut out of single pieces of iron.

The guard shown in Fig. 63 (*d*) is a clever piece of forging, and illustrates what simple and yet refined design may be executed in this class of work. The upper and lower

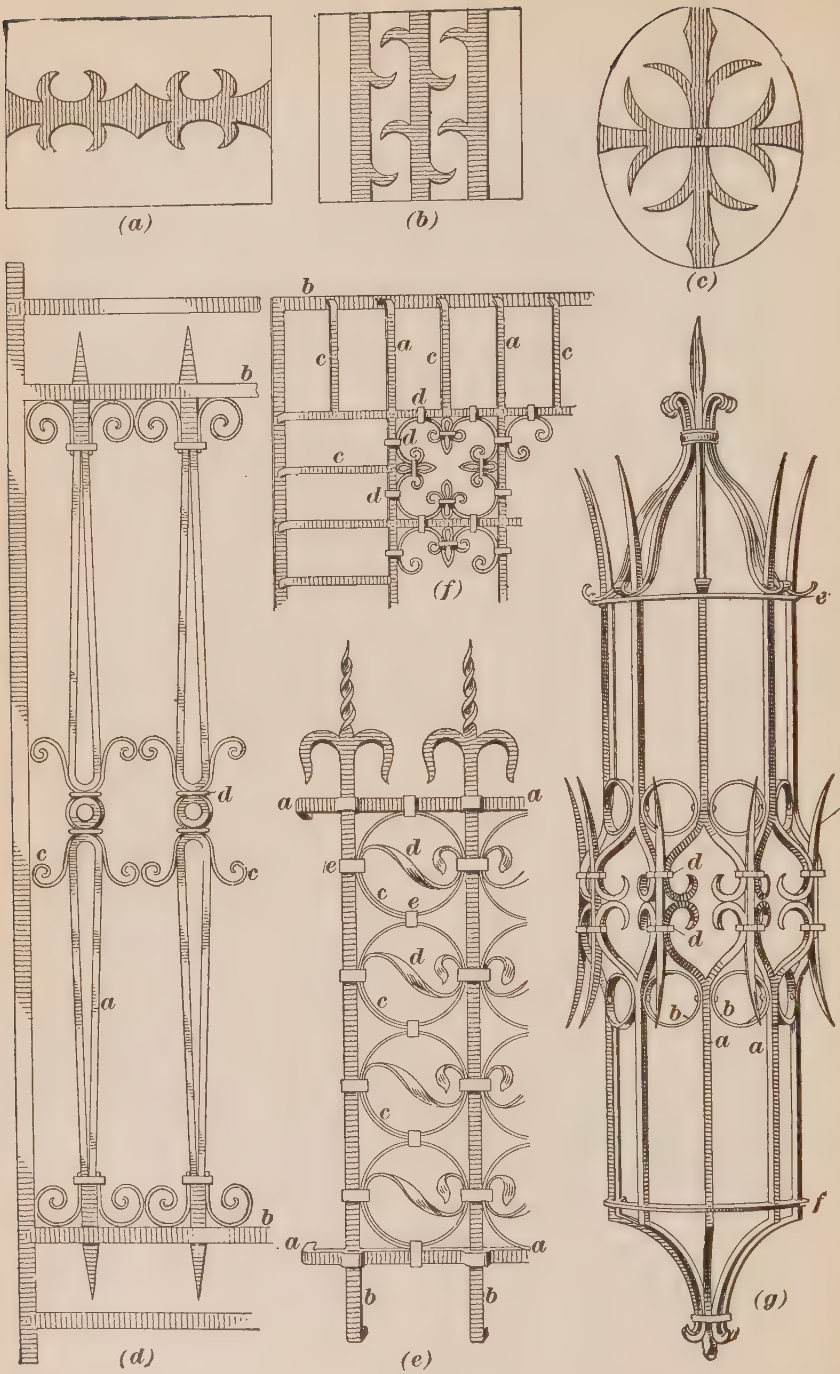


Fig. 63

parts of the bars *a* are made by bending the iron into long open loops as shown, the ends being carried through the rails *b*, a ring forged between the two interior ends, and the scrolls *c* forged to the bars and ring; the clip, or clasp, *d* encircles both ring and scroll, and binds them together.

The design shown in Fig. 63 (*e*) is very old in style, and is made to fasten to the face of the walls surrounding the window opening, the rails *a* and bars *b* being provided with return ends, which are let into the stonework about 6 inches from the edge of the window opening. The rings *c* forming the grille in this design are carried about a quarter-turn past the full circle, and the iron is twisted and flattened out in the center to form a leaf scroll *d*, which, with the rings and bars, is held in place by the flat clips *e*. The bars are drawn out and cut into three prongs at the top to form a cresting, the center one being twisted and the other two bent down to give ample protection to the top of the opening.

The design shown in Fig. 63 (*f*) is constructed for use either on the wooden window frame or on the face of the wall surrounding the window. The bars *a* forming the large square mesh are welded together, and extend beyond the mesh a distance equal to its width, and are then bent back 4 inches and welded to the frame *b*; intermediate pieces *c* are set between them, and a border is thus formed. The angles of the mesh are filled with scrolls as shown, which are held in place with flat clips *d*.

41. The guard shown in Fig. 63 (*g*) is an example of how effectively iron may be employed in decorating an otherwise plain opening, and transforming it into one of the attractive features of a house front. This guard is intended to cover a small window opening, which would almost escape observation without it, and certainly add nothing to the design of the building, though necessary for lighting the interior. This guard is made up entirely of different sizes of bar iron. The principal feature is the manner in which the bars *a* are divided just above the circles *b*, which are riveted to them, the divided portions being wrought into scrolls,

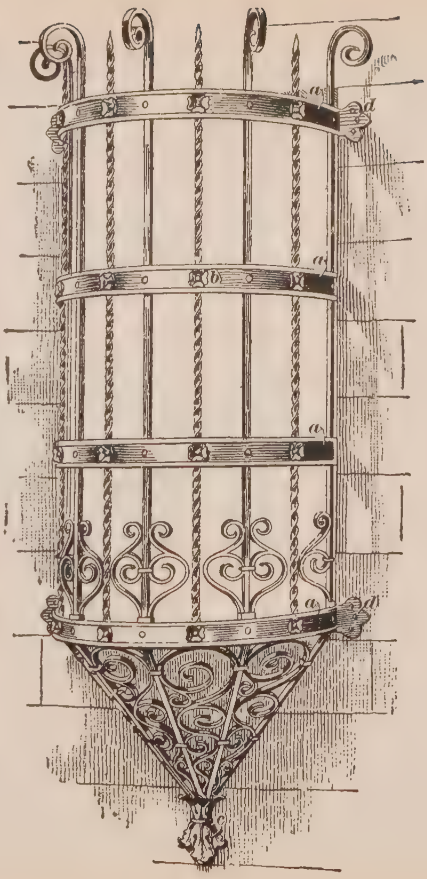


FIG. 64.

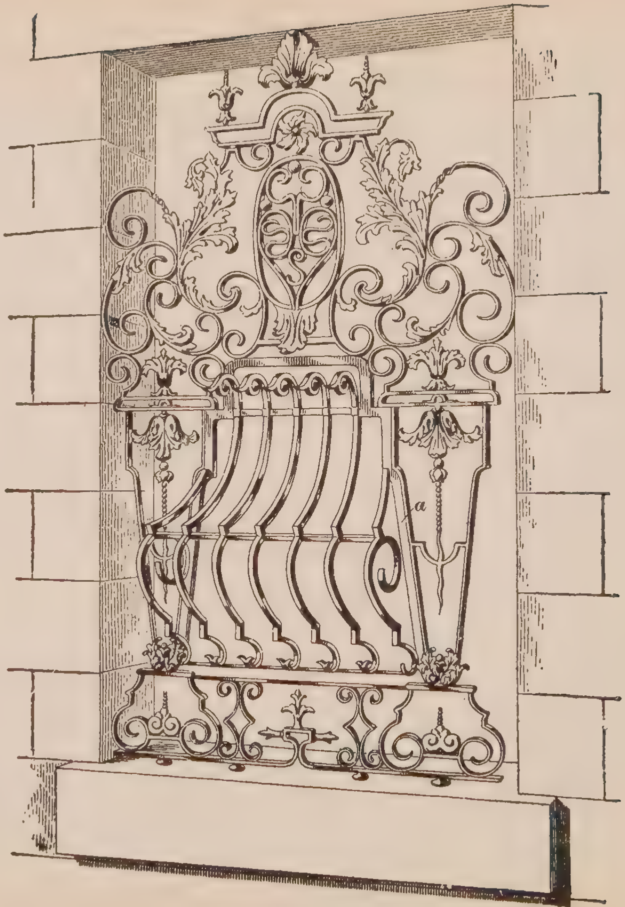


FIG. 6

which are welded to the spikes *c*, and are further bound by the strap clips *d*. The tops of the bars are finished with spike points, passing through a band *e* and through the bars forming the top, and are welded together. The guard is attached to the opening by the ends of the bands *e* and *f* bent to form lugs, which are calked with lead into holes cut for them in the stone jambs.

In the guard shown in Fig. 64, the horizontal bands *a* not only greatly increase the protection, but, with the ornamental studs or rosettes on their faces, add much to the decorative effect. These studs *b* are riveted on over each twisted bar. The edges of the bands are turned over, forming a border or flange, strengthening and giving them a finish. The twisted bars terminate at the lower band, and the plain bars are carried down, all meeting in a point, where they are welded together and covered at the junction with a leaf ornament *c*. The twisted bars are pointed at the top, and the plain ones are finished with a scroll. The entire lower portion of the guard is filled with a scroll grille, and a dado of scrolls is filled in between the bars above the lower band. The guard is fastened to the stone with expansion bolts let into the stonework through the ornamental bolt plates *d*.

42. The design shown in Fig. 65 has many points in its favor from both a structural and an ornamental standpoint. It is constructed almost entirely of forged bar iron, with just sufficient leafwork to relieve the monotony of single lines. The design is so open that the interference with light, ventilation, or outlook is inconsiderable; but at the same time it is strong, secure, and well adapted to its prime purpose as a guard. The presence of the leafwork in the upper part gives this device an appearance of lightness and delicacy, but observation will reveal that behind these leaves heavy wrought bars give the strength that the purpose of the device requires.

43. The preceding window guards are all designed for the purpose of preventing access to the building, where the windows can be easily reached from the outside; but guards are also placed across window openings at the higher stories where the sills are very low, to insure safety against the possibility of any one falling therefrom. They are used also merely as part of the ornamentation of the façades of buildings, although this practice is hardly defensible. Figs. 66 and 67 belong to this class, the former being entirely of wrought iron. Fig. 67 is mostly of cast iron with wrought-iron framing bars. The two main posts are doweled into the stone sill, and the top bars are screwed to the iron window jambs at each side. It is made thoroughly rigid by being braced back to the two mullions.

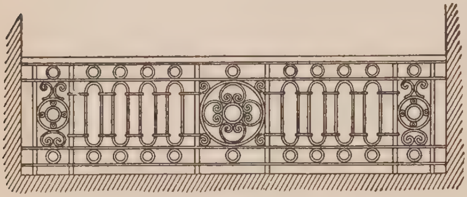


FIG. 66

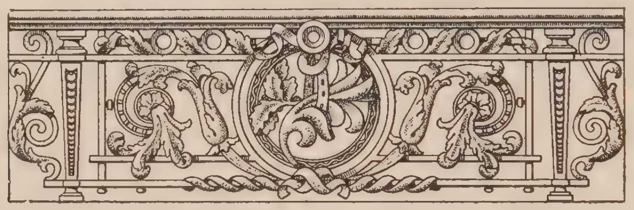


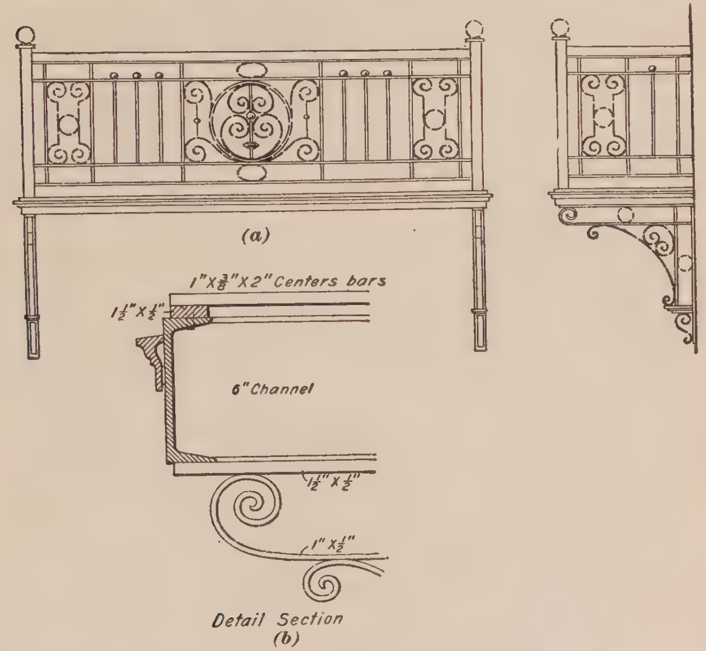
FIG. 67

BALCONIES

44. Balconies of stone or of wood often add to the appearance of a building, but they lack the light and graceful effect of those made of iron.

In Fig. 68 (*a*) is shown a light balcony very simple in design, that is made entirely of wrought iron. The floor is composed of flat bars spaced 1 inch apart. Along the face of the wall is a light angle iron, which is bolted to the stonework. The front and ends are formed of 6-inch channels supported on brackets, as shown in Fig. 68 (*b*), the face of the channels being relieved by a small molding. The railing is composed of $2'' \times \frac{1}{2}''$ horizontal bars, $\frac{3}{4}$-inch square vertical bars, and $\frac{3}{4}'' \times \frac{1}{4}''$ scrolls; it is capped with a $2\frac{1}{2}$-inch brass-pipe rail resting on a 2-inch channel. The corner posts are $2\frac{1}{2}$ inches square, surmounted with a brass ball.

Balcony work, like all other ornamental ironwork, has a wide range, and embraces every design from the simple one just described to the massive continuous example shown in *Ornamental Metal Work*, Part 1. The railings may be straight or curved, plain or foliated, according to the demands of the building they are to adorn. It will be noticed that several of the grilles and panels shown can be used as balcony railings, some without any alteration to the design at all.



Detail Section
(b)

FIG. 68

LAMPS AND BRACKETS

45. For exterior and interior lamp posts and brackets, wrought scroll-and-leaf work lends itself most readily. There is no detail of house furnishings wherein wrought iron can be put to such effective use in decoration as in electric and gas fixtures. The necessary presence of the wire conduit or gas pipe forms the purely utilitarian element of the design, and is so easily disposed of that the designer may devote nearly all his energies to the perfection of the ornamental details and the grouping in the composition. It may be well also to state that in addition to the ironwork itself another consideration materially affects this style of design, and that is the forms of electric lamps and globes with which the fixtures are to be furnished. Electric lamps may be obtained in all sizes and styles, from the large 300-candlepower, strictly for commercial use, to the small single- and half-candlepower globes used for decorative purposes. The latter are frequently mounted on the end of white-glass tubes blown in representation of wax candles, a number of which are grouped in one candelabrum or bracket, diffusing the soft unobtrusive glow of old-fashioned candle light, without the offensive grease, smoke, or smell. Again, these same diminutive lamps are enclosed in china globes representative of various flowers, such as the rose, lily, morning glory, etc., and the bracket that supports them is correspondingly designed to suggest the details of the foliated bush or vine.

46. The lamp in most common use is the 16-candlepower size, and Fig. 69 shows the neat arrangement of one

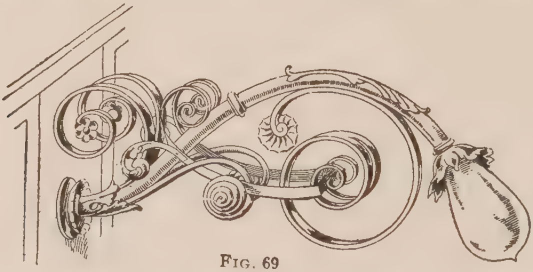


Fig. 69

of these globes at the end of a wrought-iron wall bracket. The design is extremely simple; the tube containing the wires extends in a curve from the wall to the lamp. Iron scrolls appear to emerge from the small foliated wall plate with the tube, and help support it on the outside, while the lamp is so set that its light will not cast the shadow of any part of the fixture.

Fig. 70 shows a similar design, somewhat more ornate, though precisely the same in principle. The tube, or conduit, forms, as it protrudes from the leafwork, the main stem of a floral device, from which scrolls branch out at each side, and at the termination of which is the blossom consisting of a 16-candlepower lamp, surrounded by a calyx of wrought-iron leaves. The essential points of difference between Figs. 69 and 70 lie in the fact that the former consists almost entirely of strap-iron scrolls, while the latter is primarily a foliated design the scrolls of which exist as a part of the floral composition, and do not, as in Fig. 69, form the structural scheme of the design. The long wall plate in Fig. 70 renders this bracket much stiffer than the former one, particularly as the scroll on the curve of the conduit tends to tie the wall plate and bracket in two places. The scrolls in Fig. 69 might serve a similar purpose, but not without impairing the desired effect of a single tube springing abruptly from the wall surface.

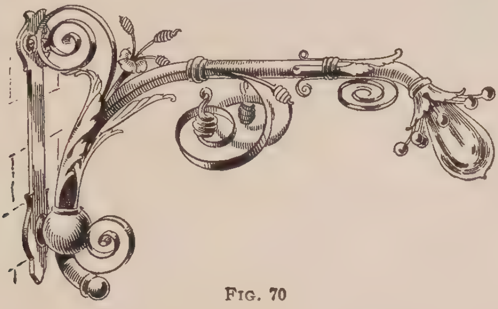


FIG. 70

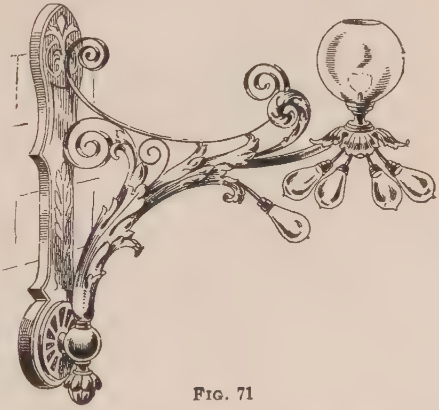


FIG. 71

47. In Fig. 71 is illustrated a combination bracket designed for both gas and electric light. Here the wall plate is much heavier, and though the general scheme of design is similar to the example shown in Fig. 70, the leaf and ornamental work is heavier, as is required by the presence of more electric lamps and a gas globe. The main tube, or conduit, contains both the electric wires and the gas pipe, and as it terminates in a spray of four lamps and one gas jet, it must appear sufficiently strong and well proportioned to carry these details successfully; hence, the extra leafwork to give its body bulk and weight, together with the scrolls that appear to support it from above. Behind these is the wall plate that apparently carries the weight of all, and is therefore made bold and substantial in proportion to the work it has to do.

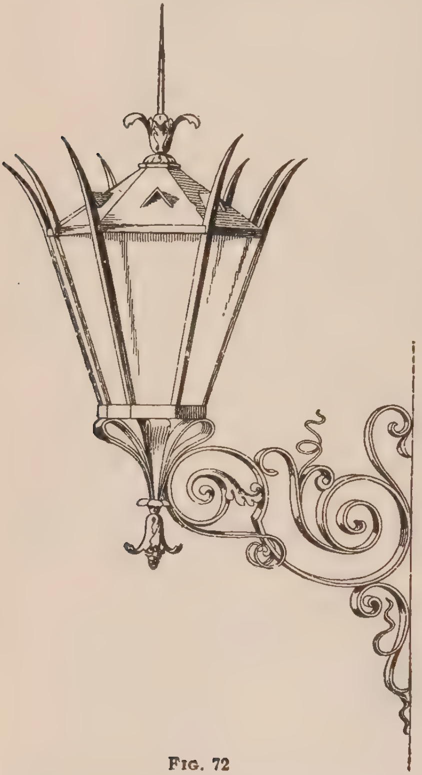


FIG. 72

48. Bracket and gate lanterns of various forms are used on the entrance posts flanking a gate, or are suspended over the gate by means of a scrollwork arch. Fig. 72 shows a bracket lamp, the body of which is made of sheet iron and glass. The pyramidal sheet-iron roof—or *canopy*, as it is sometimes called—is pierced by eight small ventilators and is finished on top with a foliated finial. The scrollwork connecting the lantern to the wall is composed entirely of strapwork, and is secured to

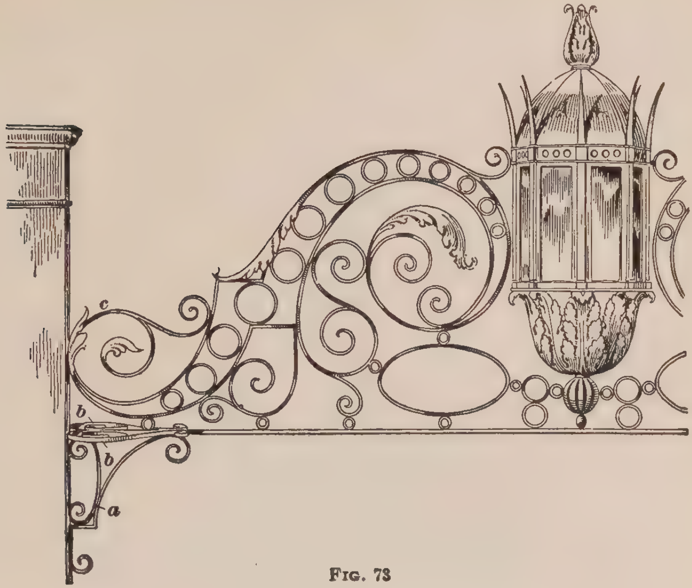


Fig. 73

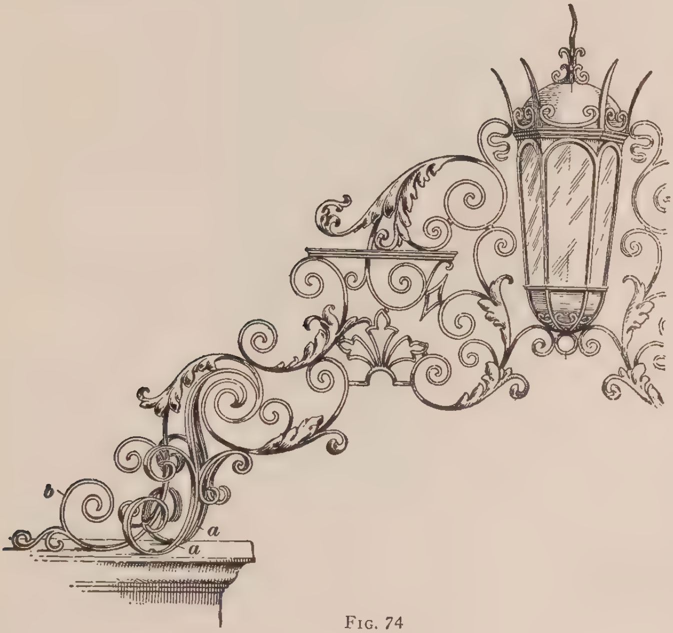


Fig. 74

the masonry by means of expansion bolts. Strength and simplicity are the fundamental principles to be looked out for in this class of work.

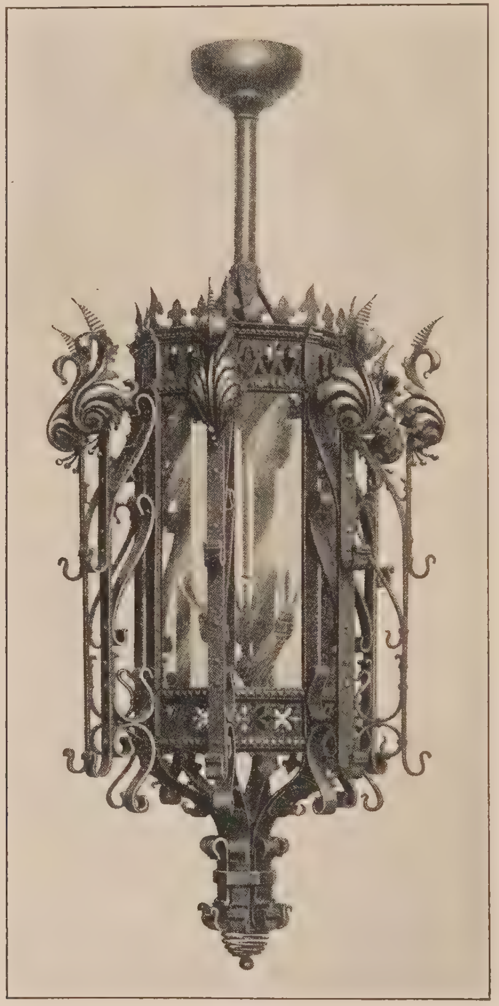


FIG. 75

The gateway lanterns shown in Figs. 73 and 74 are made of a combination of cast, wrought, and sheet iron. The design shown in Fig. 73 is intended to be placed between gate posts, and is provided with the bracket scrolls *a* to distribute and support the weight with the scrolls *b* to brace the grille laterally, and with the scroll *c* to prevent any tendency toward a rotary movement. The iron arch in Fig. 74 is designed to rest on the top of gate posts, and the scrolls *a* are so arranged at the foot of the arch that they prevent any lateral movement or tendency to revolve, the weight being well distributed and also a firmer hold being obtained by extending the large scroll *b*.

49. A very beautiful design of a wrought-iron pendant lantern is shown in Fig. 75. It is intended to hang under an archway or any similar position. It will be agreed that the primary use of a lantern is to shed light; and if this were all, then such a design as here shown would not fulfil the condition to the best advantage. But this is not all. Lights may be very properly used decoratively as well as for purposes of illumination, and this is a case in point. The light serves the purpose of marking the middle of the archway, and since that is all that is desired, the designer has felt able to elaborate and beautify the inner case by the addition of sprays and bands with graceful, hammered leaves. This is another illustration of what has already been stated, to the effect that the successful designer should constantly bear in mind, not only the individual article he may be engaged on at the moment, but its real object, whether entirely utilitarian or partly decorative, and its relation to its environment.

LAMP POSTS

50. Brackets and hanging lanterns, however, cannot be used in every case, and naturally the next form to suggest itself is that of a post, or column, which may be either a single shaft or a central shaft with clusters of brackets surrounding it. These posts may be short or long, slender or massive, sometimes forming the termination of the stone posts of a gateway or may be in the shape of a candelabra set on the stonework of an entrance. Fig. 76 illustrates an example of the former while Fig. 77 shows the candelabra type.

51. Fig. 78 shows a form of lamp post, the design of which is suggestive of a giant candelabrum. The base and shaft of cast iron are octagonal in plan, and support the three spherical globes containing the electric lamps. The arms supporting the globes are simply designed with just a suggestion of foliated work in the details. The globe may be of opalescent or ground glass, in order to diffuse the light from the electric lamps within, of which there may be three or more to each globe, according to the illuminating requirements. This style of lamp post is frequently used as a luminant for the porch of a private residence, hotel, or club, but for street lighting where the arc light is used, a different form of post is required, owing both to the difference in the form of the lamp and to the care attendant on its maintenance. Fig. 79 shows the style of support suitable for the latter case. It is executed in cast iron, as was the design shown in the previous example, but owing to the difference of its purpose the entire character of the design is changed.

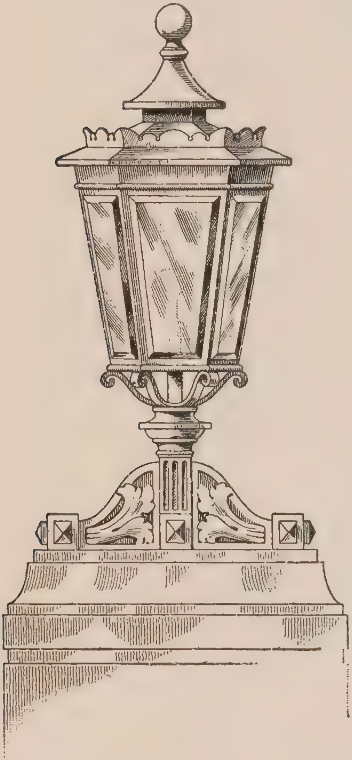


FIG. 76

In the first place, the post shown in Fig. 79 is much heavier and bulkier than the one in Fig. 78 for the reason that it is likely to receive somewhat rough usage from passing vehicles or careless draymen. Posts for street use should never be made so slender as to be easily broken. The upper portion of the post shown in Fig. 79 is designed as a loop or wicket, in which the arc light hangs under a protective roof, or hood.

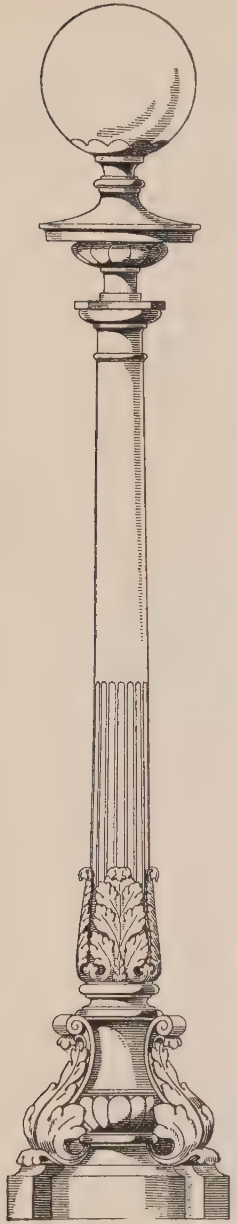


Fig. 77

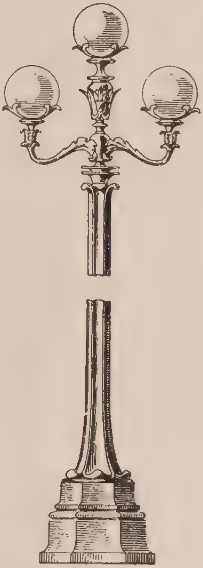


Fig. 78

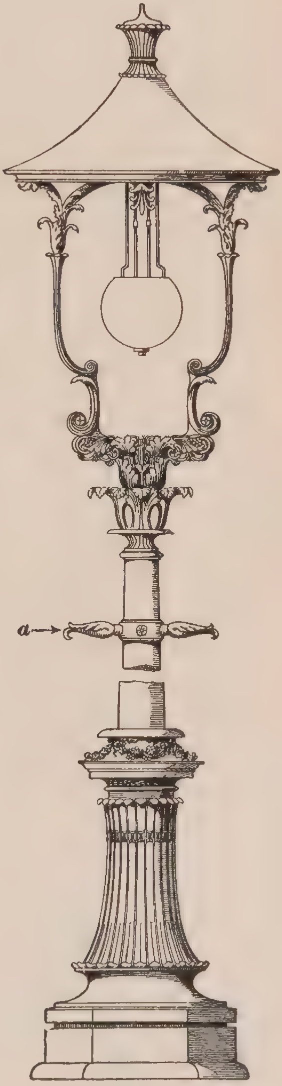


Fig. 79

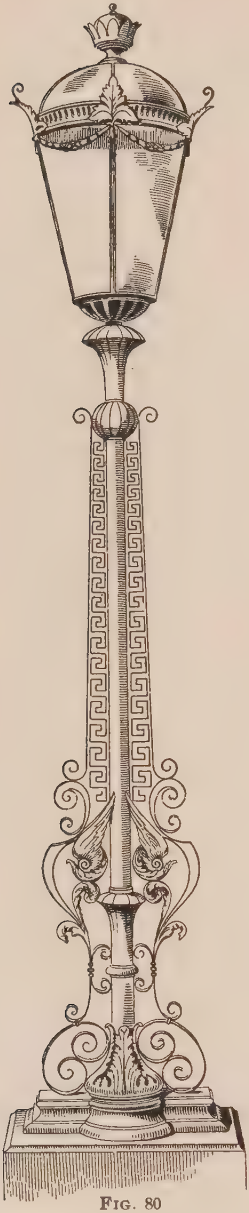


FIG. 80

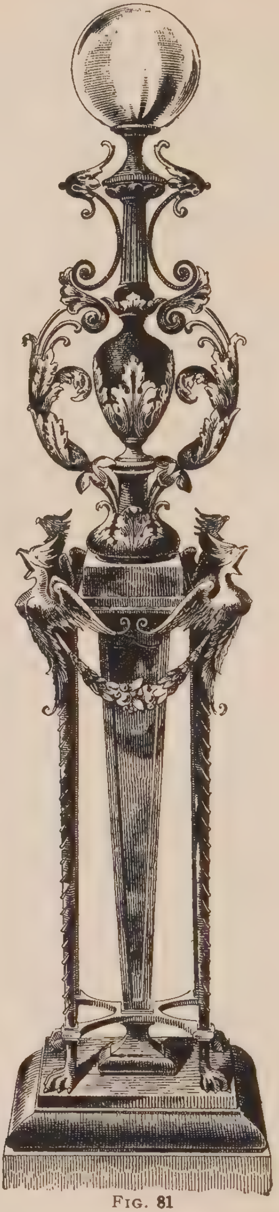
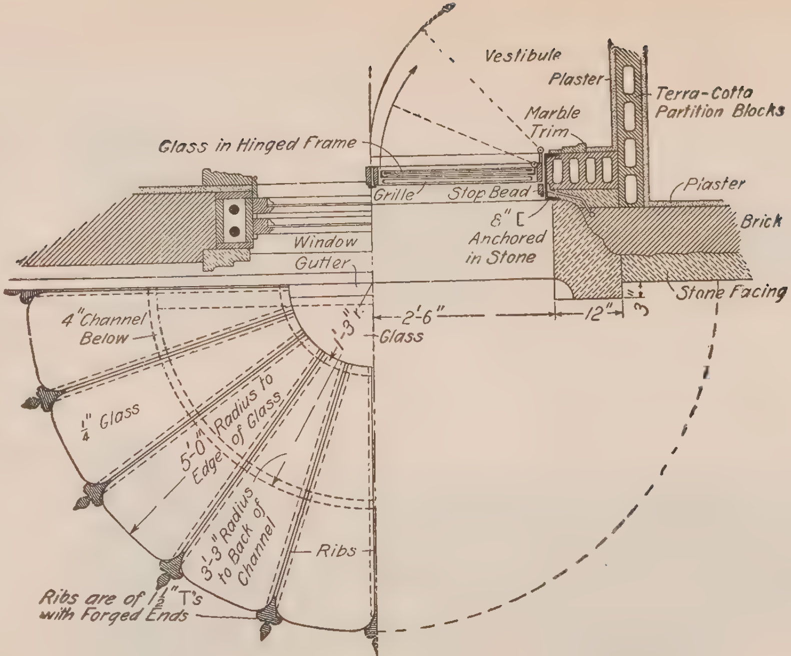
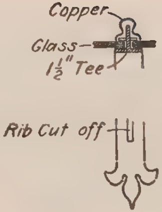


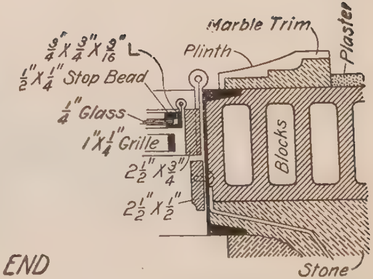
FIG. 81



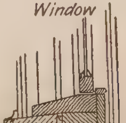
HALF PLAN OF ROOF | HALF PLAN OF DOOR



PLAN OF END


Marble Trim
Plaster
Plinth
$\frac{3}{4}$" X $\frac{3}{4}$" X $\frac{3}{16}$" L
$\frac{1}{2}$" X $\frac{1}{4}$" Stop Bead
$\frac{1}{4}$" Glass
1" X $\frac{1}{4}$" Grille
$2\frac{1}{2}$" X $\frac{3}{4}$"
$2\frac{1}{2}$" X $\frac{1}{2}$"
Blocks
Stone

SECTION OF JAMB



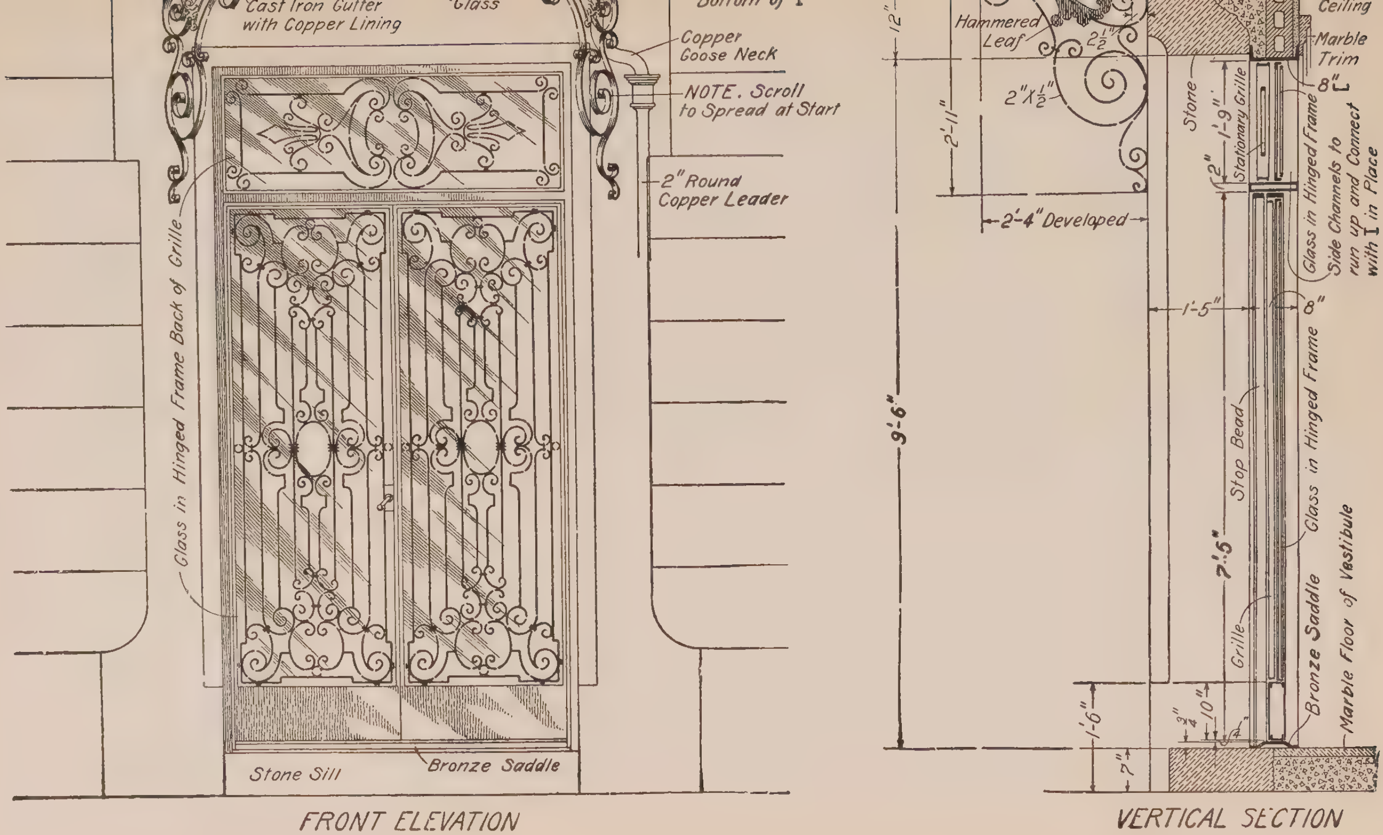

Cast Iron Gutter
with Copper Lining
Glass
Copper
Goose Neck
NOTE. Scroll
to Spread at Start
2" Round
Copper Leader
Glass in Hinged Frame Back of Grille
Stone Sill
Bronze Saddle
FRONT ELEVATION
12"
Hammered
Leaf
$2\frac{1}{2}$"
2"X$\frac{1}{2}$"
2'-11"
2'-4" Developed
9'-6"
1'-6"
7"
Ceiling
Marble
Trim
8"
Stone
1'-9"
Stationary Grille
2"
Glass in Hinged Frame
Side Channels to
run up and Connect
with I in Place
1'-5"
8"
Stop Bead
7'-5"
Glass in Hinged Frame
Grille
$\frac{3}{4}$"
10"
4"
Bronze Saddle
Marble Floor of Vestibule
VERTICAL SECTION

Fig. 82

Thus it is seen that its exposed position requires the street lamp to be heavy and strong, and that the character of the light it carries determines the form of its top, while the maintenance of the arc light requires the two projecting rungs *a* against which a ladder may rest or on which a person may stand when adjusting new carbons or cleaning the globe and copperwork.

52. In Fig. 80 is shown a form of post for a gas lamp. The main shaft, or post, is of cast iron, on which the fretwork and scrollwork of wrought iron is secured with countersunk screws. The lantern at the top consists of glass plates mounted in a wrought-iron frame, which is covered with a dome-shaped hood. This lantern encloses the gas jet or jets and protects the flame from the wind. The scrollwork of this design is so delicate that it is hardly suited for a much exposed position, such as a street light, but for courtyards and lawns or for park walks it is admirable, combining delicacy and refinement of design with simplicity and economy of construction.

The lamp shown in Fig. 81 is an elaborate design in cast and wrought iron, and is suitable as a porch light or as one of a series of lights arranged in a courtyard. The main body is of cast iron, decorated and relieved with wrought-iron leafwork, which is secured to the cast-iron standard with countersunk screws. The design is suggestive of an antique, standard, and torch; only, where the flame of the torch would have existed in ancient art, the globe and electric lamp are present here. The globe in this case should be of opal or ground glass, for reasons similar to those stated in connection with Fig. 78.

CANOPIES AND PORCHES

53. Of canopies, marquees, porches, etc., there is endless variety. They are peculiarly adapted for execution in wrought and cast metal, and may be seen in all sorts of forms—fan- or dome-shaped tops, with and without brackets, curved or straight roofs, sometimes projecting out over the sidewalks to the edge of the curb.

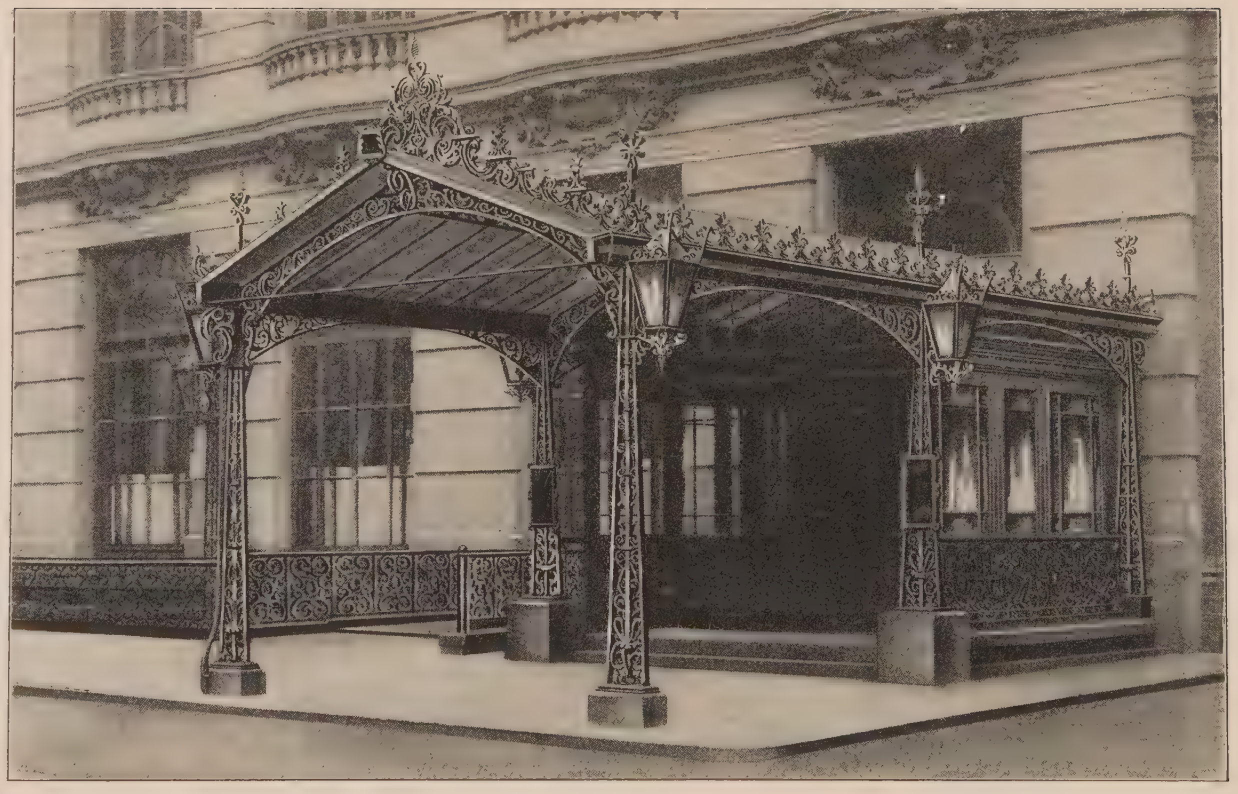


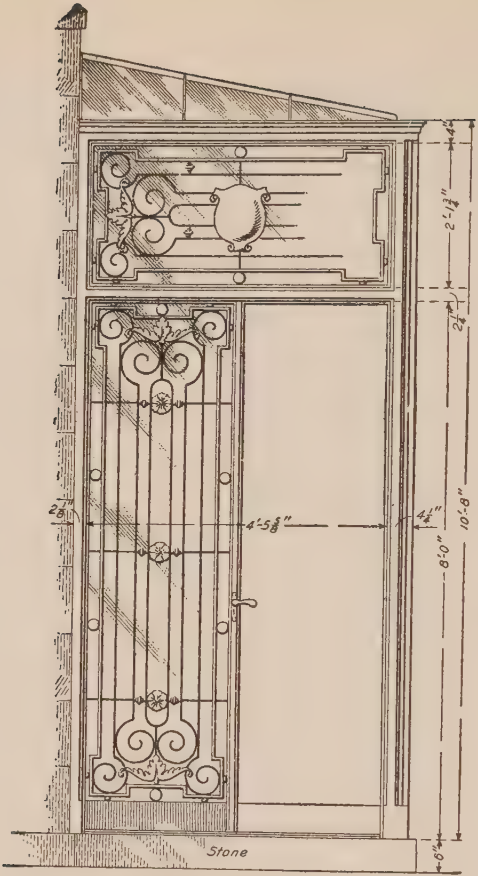
FIG. 83

An example of a fan design (this type is usually called a marquee) is given in Fig. 82 and it is only necessary to study the drawing in order to understand fully the construction. This style of canopy has rather a graceful effect over an entrance to a residence. As will be seen, it tilts back toward the wall, where the water is carried off by a copper gutter leading into a vertical pipe. The entrance doorway shown in the same drawing is similar to Fig. 84 and is built up in the same way.

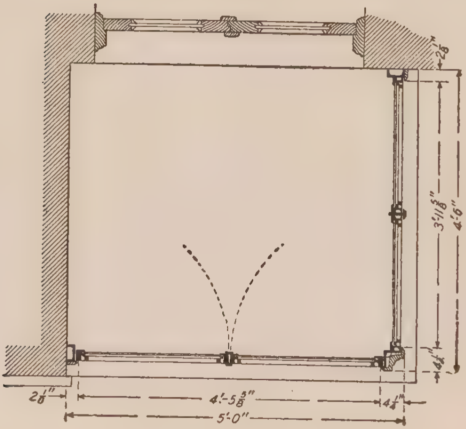
54. Fig. 83 is a carriage porch and entranceway built of wrought iron. The supporting columns spread out toward the bottom, giving an impression of strength as well as lightness. Branching from the columns on each side of the porch are lanterns of appropriate design. The roof of ribbed glass is supported by trusses of graceful design, while it is also furnished along the sides and over the front of the peak with crestings and terminals. In addition to being an important part of the architectural scheme, this porch as a whole forms a protection from sun or rain.

55. Somewhat similar to the porch just mentioned, but differing in that it is rather a vestibule, is the structure shown in Fig. 84 (*a*), (*b*), (*c*), (*d*). This vestibule is built in the angle of the building in front of the entrance. As far as the metal parts are concerned, it consists of the front, side, and roof, as can be seen from the plan in Fig. 84 (*b*). The detail sections in Fig. 84 (*c*) and Fig. 84 (*d*) show the construction of the enclosure.

The principal framing consists of 3-inch vertical channels placed next to the walls, a 3″ × 3″ angle at the corner, and an intermediate 2″ × $\frac{1}{2}$″ molded **T** bar in the middle of the side, dividing it into two panels corresponding to the design of the front. The bottom ends of these uprights are fastened to the stonework with expansion bolts or calked into holes in stonework. At the top, they are bolted to the cast-iron cornice or gutter, the ends of the cornice being embedded and calked in the stonework of the building. All of the exterior lines of the gutter are of course horizontal,



Front Elevation
(*a*)



(*b*)

FIG. 84 (*a*), (*b*)

but the inner surface of the bottom should be made slightly inclined throughout its whole length back toward the wall of the house. This will allow rain water to run off to a point where it is conducted by a pipe to the ground, either on the outside or inside of the wall. If the gutter is lined with copper, as is sometimes done, the fall can be formed in the lining.

The doors and side are glazed with clear plate glass behind the grille-work, and in order that the glass may be accessible for cleaning, the grille panels are hinged. If it is preferred, the grilles may be fixed and the glass panels hinged. The frames of the doors are made of $1\frac{1}{2}'' \times \frac{7}{8}''$ and $1\frac{1}{2}'' \times \frac{3}{4}''$ flat bars, to which is screwed the square rabbets. The glass is placed against these rabbets and is held in position by the flat bar corresponding to what would ordinarily be the stop-bead. In case the glass becomes broken, this flat bar is easily unscrewed and the glass replaced. The bars and scrollwork are made of $\frac{5}{8}'' \times \frac{1}{2}''$ and $\frac{5}{8}'' \times \frac{3}{8}''$ material. The

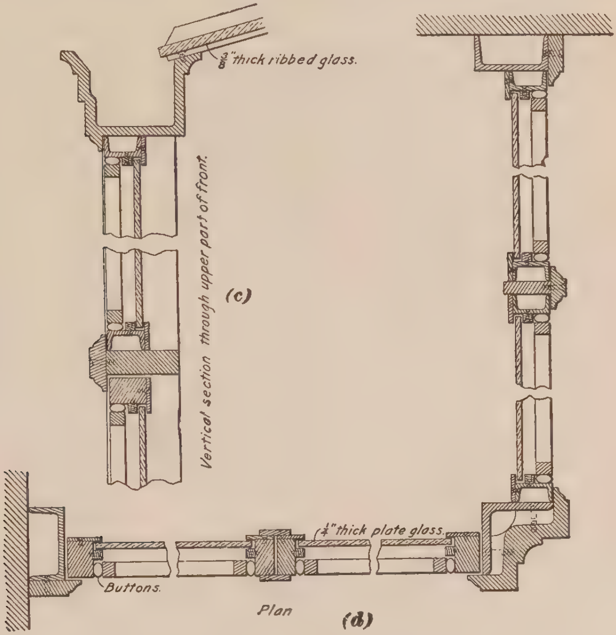

$\frac{3}{8}''$ thick ribbed glass.
Vertical section through upper part of front.
(c)
$\frac{1}{4}''$ thick plate glass.
Buttons.
Plan
(d)

FIG. 84 (*c*), (*d*)

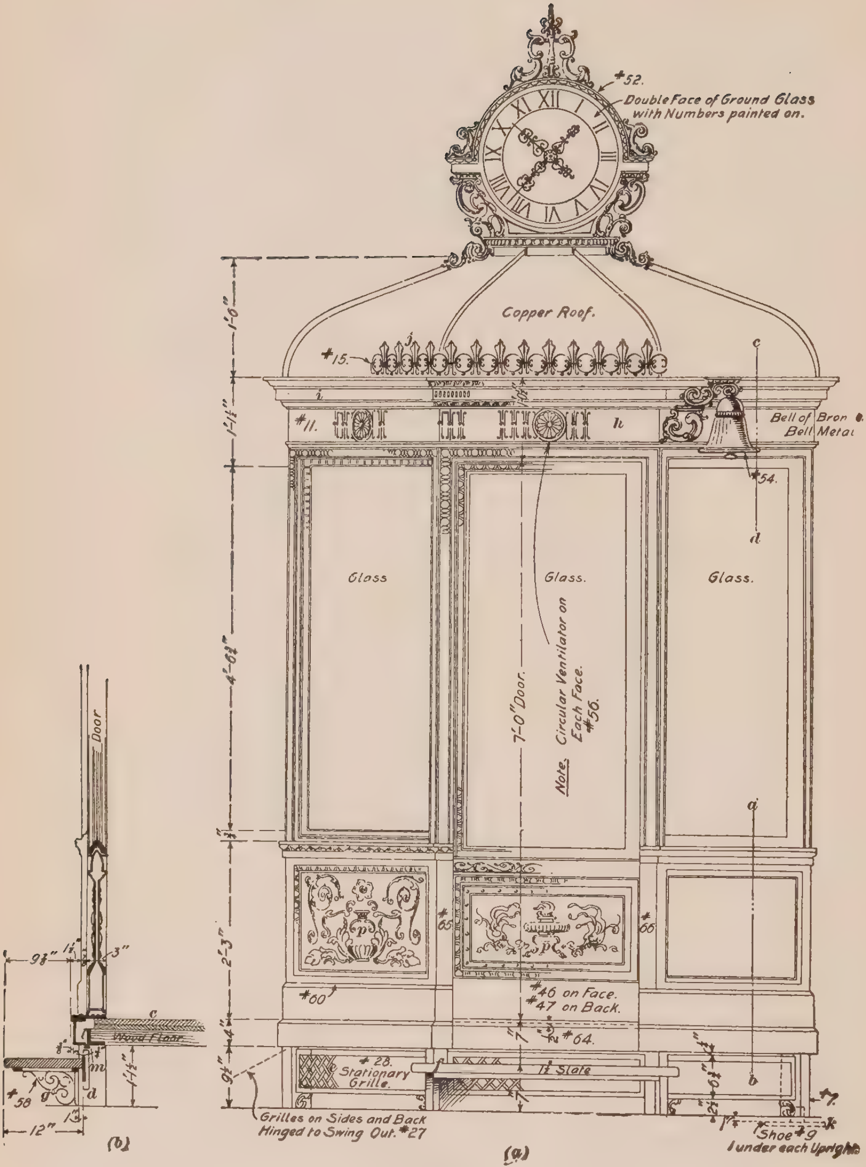

#52.
Double Face of Ground Glass with Numbers painted on.
Copper Roof.
j
#15.
i
#11.
h
c
Bell of Bron
Bell Meta
#54.
d
1'-6"
1'-1½"
4'-6¾"
¾"
2'-3"
4"
9½"
Glass
Glass.
Glass.
7'-0" Door.
Note: Circular Ventilator on Each Face. #56.
a
#65
#66
#60
#46 on Face.
#47 on Back.
#64.
#28. Stationary Grille.
1½ Slate
Grilles on Sides and Back Hinged to Swing Out. #27
b
#7.
k
Shoe #9
1 under each Upright
Door
9¾"
1½"
3"
c
Wood Floor
m
1'-1½"
#58
g
d
13
12"
(b)
(a)

FIG. 85

side and transom panels are very similar to the doors, except that the frame, being stationary, is fitted close against the main bars, and is formed of channels instead of solid metal. The cast-iron moldings and trim are added to give finish to the structural parts. The roof is composed of 1¼-inch **T**'s set about 1½ feet apart and is glazed with ribbed glass ⅜ inch thick, thus completing the structure.

The details of the pivots and lock for the doors are not shown. They should be drawn full size and arranged to suit conditions.

As a matter of practice, it would be well for the student to design a similar porch, changing the dimensions and sizes of material.

IRON STRUCTURES

56. It is sometimes desirable to erect small structures entirely of cast and wrought iron. Of these, the most common are the small domes or cupolas crowning the roofs of certain classes of buildings, and occasionally small detached buildings used as offices for the sale of tickets at the entrance of places of amusement, or as an adjunct to some branch of a general service system, as is the example hereafter shown. In any case, the structure is necessarily of an ornamental character, and must accord in design with surrounding conditions.

An example of a detached iron structure is shown in Fig. 85. The entire edifice is constructed of cast- and wrought-iron framework carrying a copper roof and heavy plate-glass window lights. The purpose of the building is that of a cab office in connection with the service of a hotel, club, or theater. The plan is octagonal, as shown in Fig. 86, each angle of the octagon being marked by a hollow cast-iron upright, molded to form the architraves of the window and door openings, and at the same time to contain the **T**-iron supports *d* of the roof and superstructure. These supports extend to the ground in each case, and stand on an iron plate, or shoe, as shown at *g* in the elevation, Fig. 85 (*a*), and between them is framed an angle iron, to receive the ends of the floorbeams, as shown at *l* in the section, Fig. 85 (*b*). The space from this angle to the ground is filled with an iron grille, as shown in the elevation at *e*, while from the floor to the window level a cast-iron plate encloses each side of the octagon with an ornamental panel *p*.

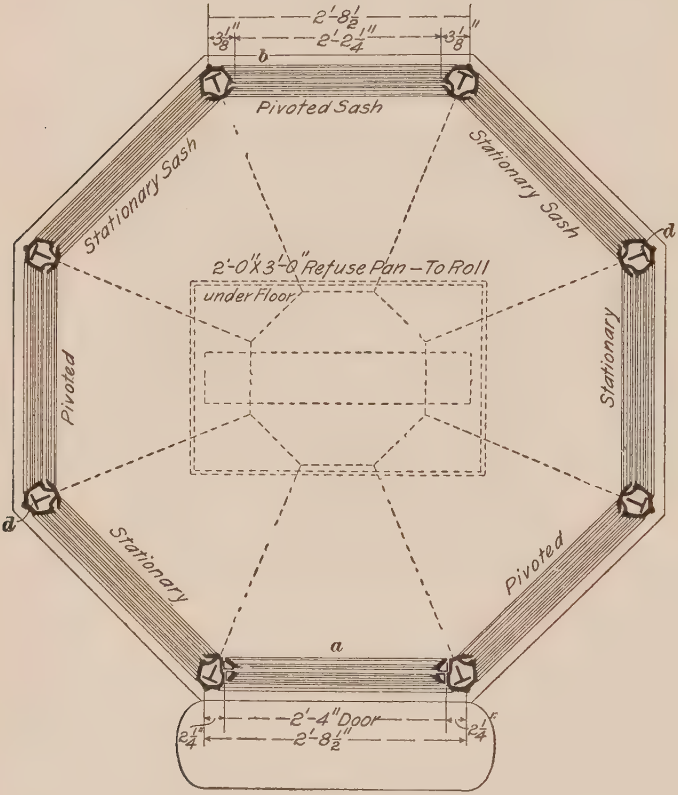


FIG. 86

The construction of this paneled dado can be better understood from Fig. 87, which is a section taken on the line *a b*, Fig. 85 (*a*). The angle iron framed between the vertical **T**'s, as shown at *l*, Fig. 85 (*b*), is here seen in section as piece *#32*, and outside of it is the cast-iron facing of the structure, consisting of a water-table 4 inches in height, and the plinth,

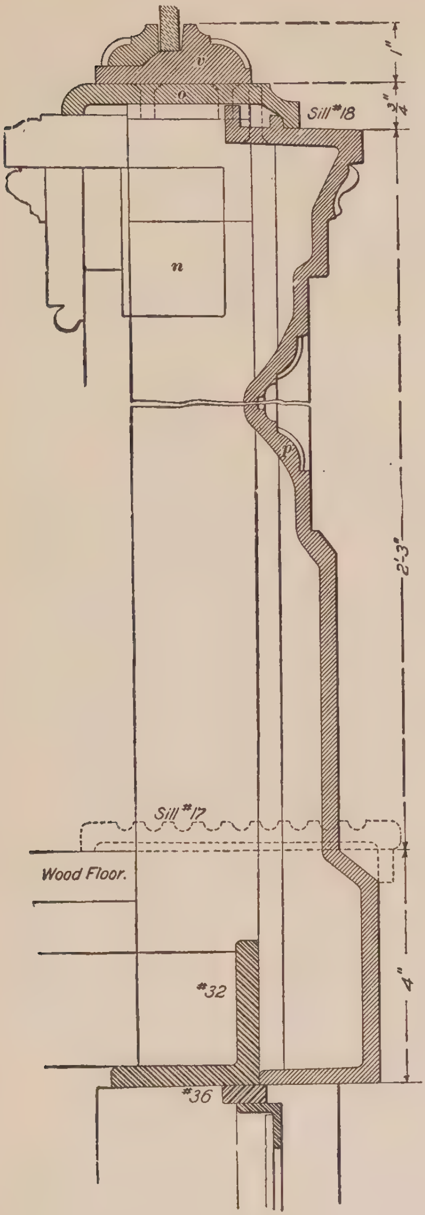


FIG. 87

panel, and window sill extending 2 feet 3 inches more. The sill cap *o* is secured at each end to angle-iron knees or brackets previously riveted or bolted to the vertical **T** supports. These sill caps extend over the top of the panel pieces and hold the latter in place by clamping over a rib piece cast on the top of the main panel, the panel pieces being fastened to the **T** supports by screw bolts. On this sill piece *o* rests the sash as shown at *v*, and on the inside of the office is secured the wood trim that forms the finish under the sill.

57. In Fig. 88 is shown a section through the cornice on the line *c d*, Fig. 85 (*a*). This cast-iron cornice is fastened at each end to the **T**-iron uprights with screw bolts, and thereby braces and secures these uprights at the top. The inside cornice *r* is secured in place by means of the wrought-iron strap *s* bolted to the main cornice, and to which the inside cornice is fastened with screw bolts. Observe that these screw bolts do not pass through the sash head, but simply secure the two pieces of cast-iron cornice to the strap or bar *s*, as this sash is to be pivoted (see plan).

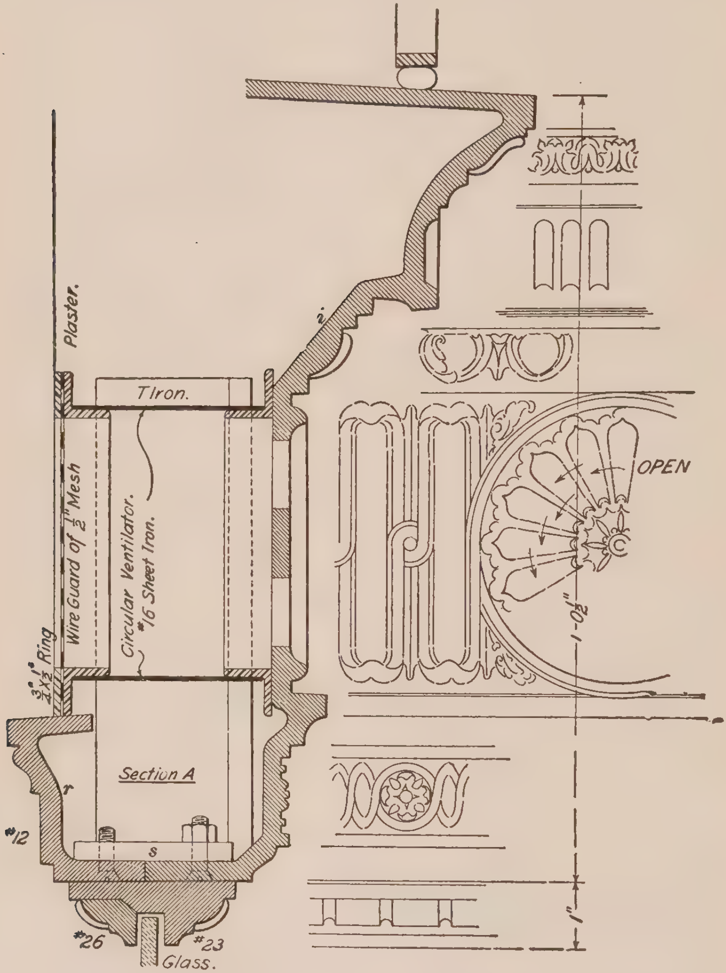


Fig. 88

In Fig. 89 (*b*) is shown a section through the lower part of the cornice where the sash is intended to be stationary (see plan). The inside or lining strap *s*, Fig. 88, is omitted in this case, and the outside cornice secures the top of the sash with a round-headed screw bolt, while the inside cornice is fastened to the sash head by a countersunk screw bolt, the sash head serving the same purpose here as did the strap piece *s* in Fig. 88. At the door opening, the lower fillet of the inside cornice is omitted, thus permitting the outside cornice to fall below it and form a stop, for the top of the door, as shown in Fig. 89 (*a*). An inside strap or bar *s* is then used to screw these cornices to, for the preservation of their alinement, while the ribs *t* cast on the

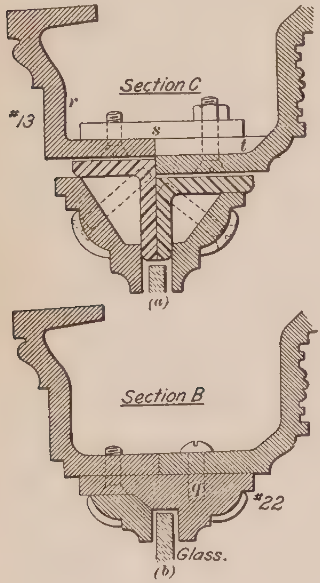


FIG. 89

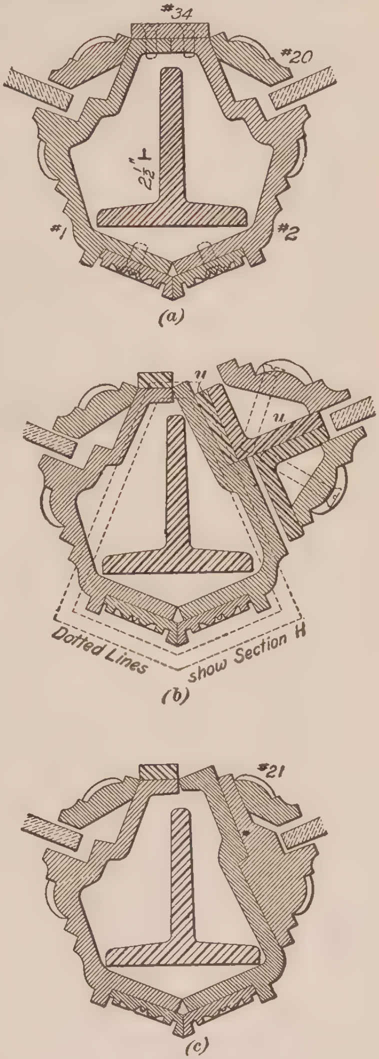


FIG. 90

exterior cornice maintain it in its proper position as a door stop.

58. The door frame is formed of two angle irons, whose legs are unequal, as shown in Fig. 89 (*a*). This inequality permits the inside angle to extend beyond the exterior one and strike (when the door is closed) against the door stop formed in the architrave or jamb casting.

Fig. 90 shows three sections through the architraves and supporting **T** irons of the main frame. At (*a*) is shown a section through the architraves of the fixed sashes, where the glass of the windows is held in place by a molding and recessions in the casting. At (*b*), the section shown is through the architrave at one side of the door, where provision is made in the casting for the door stop against which the longer-legged angle iron of the door frame shall strike; and at (*c*) is shown a section through the architrave at the side of a pivoted window sash. The glass is here shown secured in the cast-iron sash frame similar to that in Fig. 88, except that in this case a rabbet is cast in the frame and jamb against which the sash may strike when closed, and thus be prevented from revolving past the architrave.

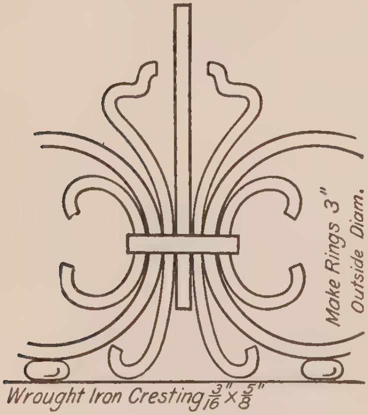

Make Rings 3" Outside Diam.
Wrought Iron Cresting $\frac{3}{16}'' \times \frac{5}{8}''$

FIG. 91

59. The roof is framed with light angle irons bent to the form shown in the elevation, Fig. 85, and covered with copper on the outside, while the inside or ceiling is plastered on wire lath. The cresting around the eaves is of strap iron, the design being simple but neat, a detail of which is shown in Fig. 91. The clock face is framed in a cast-iron ring with ornamental scrolls as shown, the details being similar to other cast-iron ornament of this character heretofore described.

60. It is hardly necessary to reiterate that the more one knows of the characteristics of the material and the methods of manufacture, the easier it will be to originate appropriate designs. There are many very interesting and curious ways of solving the difficulties of molding and patternmaking that cannot be explained at length here. The explanations given cover the subject sufficiently for the present purpose.

ELECTRIC WIRING
(PART 1)

ELEMENTARY ELECTRICAL AND MAGNETIC THEORY

DEFINITIONS AND DESCRIPTIONS

INTRODUCTION

1. Electricity.—Electricity is a name given to the cause of certain phenomena or manifestations, although the exact nature of this cause is not known. Much is known, however, about the laws governing electricity. For example, certain substances can be made to attract or repel other substances, chemicals can be decomposed, heat can be developed, and so on, by the use of electricity.

2. Static Electricity.—Electricity at rest is called static electricity. This is the kind produced by rubbing a hard-rubber comb or a piece of glass with a woolen cloth. The comb or the glass, when so rubbed, is electrified, or charged. In other words, the comb bears a static charge of electricity.

3. Dynamic, or Current, Electricity.—Electricity in motion is called dynamic, or current, electricity. Because the action of electricity in motion resembles in many respects the action of fluids in motion, it is common to speak of the *flow of electricity*. This flow is called an *electric current*. A momentary flow is generally called a *discharge*.

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4. Electromotive Force.—Force is necessary, however, to cause a flow, or current, of electricity. This force is called an *electromotive force* (e. m.f.).

5. Electric Potential.—Electric potential is a term used to signify the state or condition of a body whereby electricity tends to flow into it or out of it. If its electric potential is lower than that of another body with which it is electrically connected, electricity will flow into it. In short, electricity tends to flow from bodies of higher potential to bodies of lower potential.

6. Conductors and Non-Conductors.—Electricity, like water, if permitted to flow unconfined, selects the easiest path. The rate of flow of electricity, however, depends primarily on the nature of the substances through which it flows. Those substances through which electricity flows readily are called *conductors,* or *conducting substances,* and those offering great opposition to the flow are called *non-conductors,* or *insulators.* In order that the energy may be utilized efficiently, the current must be confined within a definite path, like a wire. To prevent the current from leaving the wire, supports of some non-conducting substances, like glass or porcelain, are used to hold the wire and prevent it from coming in contact with surrounding materials. A wire is a conductor and each support is an insulator. As a further precaution, the wire is usually covered throughout its length with rubber or some other pliable non-conducting substances called *insulation.*

7. Electric Circuit.—An electric circuit is a conducting path through which electricity will flow when the path is complete between points of different potentials. A complete, or unbroken, path between such points is a closed circuit; an incomplete, or broken path, is an open circuit.

8. The direction of current in an electric circuit is assumed to be from the condition called *high,* or *positive, potential* to the condition called *low,* or *negative, potential.* The signs + and −, respectively, are used to indicate these two conditions. Thus, electricity is said to flow from + to −.

9. Electric resistance, generally defined, is opposition to the flow of electricity. No known substance is wholly without resistance, which depends on the nature of the substance. The resistance of a conductor depends on its material and its dimensions. The resistance of a long wire is greater than that of a short wire of the same diameter and material. The resistance of a wire of large diameter is less than that of a small wire of the same length and material.

10. The electric conductance of a wire is a measure of its ability to conduct electricity. Good conducting materials, named in order, with the best conductor first, are silver, copper, gold, aluminum, zinc, brass, phosphor-bronze, platinum, tin, nickel, lead, German silver, steel, iron, mercury, carbon, and water. Copper, being plentiful and comparatively cheap, is most generally used, and aluminum is also employed for long transmission lines.

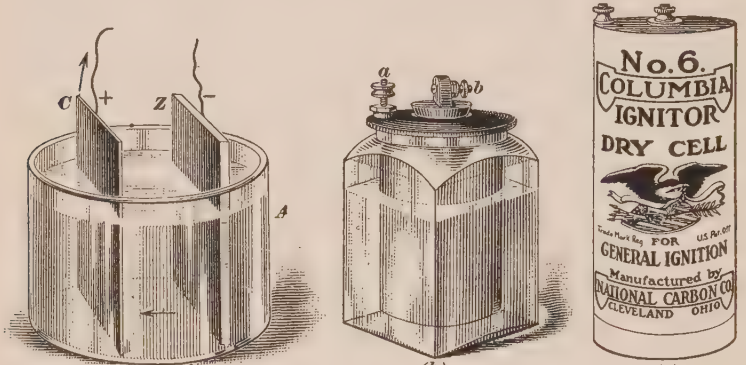
11. A resistor is a device purposely designed to oppose the flow of electricity. Resistors are a part of many heating devices and of certain types of electrical measuring instruments.

Insulating materials in general use are glass, porcelain, rubber, mica, ebonite, dry paraffined wood, prepared paper, and other fibrous materials, asbestos, pure asphalt, air, oils, and various substances of patented or secret composition.

PRIMARY CELL

12. Generation of Electromotive Force.—The methods most commonly used in generating electromotive force are: (*a*) by chemical action; (*b*) by electromagnetic induction; (*c*) by heat action. The first method is used for generating small electromotive forces and currents for electric-bell systems and alarm systems.

13. Primary, or Galvanic, Cell.—The device for establishing an electromotive force by chemical action is called a primary cell, or galvanic cell. In Fig. 1 (*a*) is shown the simplest form of primary cell, consisting of a copper plate *C* and a zinc plate *Z* immersed in dilute sulphuric acid contained in a glass jar *A*. The acid attacks the zinc more vigorously than it does the copper, with the result that the zinc plate is raised to a higher potential than is the copper plate, thus tending to cause electricity to flow from the zinc to the copper through the liquid. If the two plates are electrically connected outside the cell, as would be the case if the two conductors shown attached to the plates were joined together, electricity will flow from zinc to copper through the liquid, and from copper to zinc outside the liquid. In (*b*) is shown a type of liquid cell in common use, while (*c*) shows a dry cell embodying the same principle.



(*a*) (*b*) (*c*)

FIG. 1

14. Primary Battery.—A primary battery is a group of primary cells so connected electrically that either their currents or their electromotive forces are added. To provide a convenient means of connecting cells, either together or to external conductors, thumbscrews, binding clips, or similar devices are attached to the plates as shown at *a* and *b*, Fig. 1 (*b*). Such devices are called the cell terminals. The word *terminal* has a similar meaning when used in reference to other kinds of electrical appliances. In general, a terminal is a point at which the external circuit is connected to the internal circuit of any electrical apparatus.

KINDS OF CURRENT

15. The current generated by a primary cell has an unchanging direction with respect to its source. Such a current is called a *direct current* (D. C.). A circuit carrying a direct current is called a direct-current circuit.

An *alternating current* (A. C.) is one that reverses its direction regularly, and its path is an alternating-current circuit. Until the topic of alternating current is taken up, the following discussion applies to direct currents only.

ELECTRICAL UNITS

16. Electricity is measured by its effects or by the work it does. In order to measure these effects, it is necessary to establish units by which these may be computed. The units in common use are the ampere, ohm, volt, watt, kilowatt, kilowatt-hour, and horsepower.

17. The **ampere** is the practical unit rate of flow of electricity, or unit current. The ampere as a unit of flow of electricity corresponds to the gallon per second as a unit of flow of water. The practical unit of electrical quantity is the ampere-hour, which is equal to the flow of one ampere of electricity for one hour. The term *amperage* is sometimes used to denote the strength of an electrical current measured in amperes.

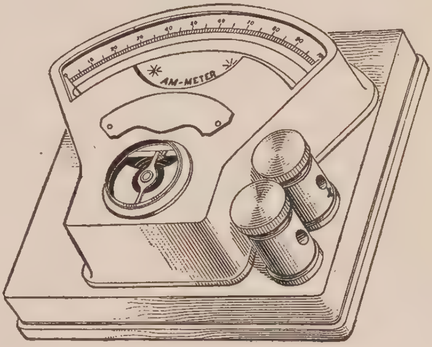


Fig. 2

18. In practical work, electric current is measured by means of an instrument called an *ammeter,* a portable type of which is shown in Fig. 2. The ends of the conductors are inserted in the terminals shown at the right, and the effect of the current in the circuit causes a pointer to deflect over the scale to a figure indicating the rate of flow directly in amperes. In this illustration the pointer is at zero.

19. The **international ohm** is the practical unit of electric resistance and is determined by the resistance of a column of mercury of specific dimensions or by a standard coil of wire. The word *ohm,* as generally used, refers to the international ohm.

20. It is customary to state that a wire of a given material having specified dimensions and at a given temperature has a resistance of a certain number of ohms. In wiring work, the value of 10.8 ohms, approximately, is often used as the resistance in ohms per foot of a uniform circular wire 1 mil (1/1,000 inch) in diameter.

21. The **volt** is the practical unit of electromotive force, and is the electromotive force that will cause electricity to flow at the rate of 1 ampere through a circuit having a resistance of 1 ohm. Derived from the unit is the word *voltage,* which is the name generally used to express electromotive force. It is easier to say "the voltage is 110" than to say "the electromotive force is 110 volts."

22. The definition of a volt shows that a certain relation exists among values of voltage, current, and resistance in an electric circuit. This relation, named after its discoverer, Ohm, is called Ohm's law, and is as follows.

Ohm's Law.—*The current in an electric circuit varies directly as the electromotive force is impressed on the circuit, and inversely as the resistance of the circuit.*

Expressing the law as a formula, using the three fundamental units,

$$\text{amperes} = \text{volts} \div \text{ohms}$$
$$\text{volts} = \text{amperes} \times \text{ohms}$$
and
$$\text{ohms} = \text{volts} \div \text{amperes}$$

Thus, any one of the three factors can be found if the other two are known.

23. In practical work, voltage is generally measured by means of an instrument called a *voltmeter,* a device having much the same external appearance as an ammeter, but designed to indicate electromotive force directly in volts. Voltmeters are made in many styles, or types, and for many ranges of voltages.

24. Work is done on a circuit when a quantity of electricity, which may be expressed in ampere-hours, is forced by the voltage to pass through the circuit. Work is required to send the electricity through the circuit, and this work can be recovered by utilizing the electric current. Work takes into consideration voltage, current, and time. A water analogy is that of the work done on a water-pipe system when the pressure applied to the water forces a quantity of water through the pipe.

25. **Power** is the rate of doing work, or power = work ÷ time. The watt is the practical unit of electric power, and 1 watt is expended when a direct current of 1 ampere is forced through a resistance of 1 ohm. The power, expressed in watts, also equals the amperes of current multiplied by the volts. In the rating and measurement of power of large electrical apparatus and circuits, the *kilowatt* (abbreviated kw.) equal to 1,000 watts, is the unit generally used. Kilowatts = watts ÷ 1,000.

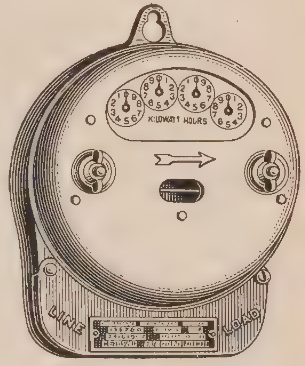


FIG. 3

26. As work = power × time, a unit of work can be derived by taking the product of a unit of power and a unit of time. Two practical units of electrical work, the watt-hour and the kilowatt-hour (abbreviated kw.-hr.), are thus derived. Electrical energy is nearly always bought and sold in kilowatt-hours.

27. The name *watt-hour meter* is applied to an instrument arranged to measure electrical work whether the amount is registered in watt-hours or in kilowatt-hours. The watt-hour meter is the instrument that is generally referred to in common electrical parlance as a *meter*. Several forms of watt-hour meters are in use, one of which is shown in Fig. 3.

SIMPLE ELECTRIC CIRCUITS

28. Series Connections.—Electric conductors can be connected in several ways. When the connections are such as to form only one path for the flow of electricity, the connection, or grouping, is a series connection and the apparatus or conductors are *in series*. For example, Fig. 4 represents a closed circuit consisting of a simple primary cell *B* and four conductors *a, b, c,* and *d* connected in series; that is, electricity can flow from the positive terminal of the cell to the negative terminal through only one path. An opening in any part of this series circuit would prevent all flow in it. In the illustration is shown the conventional way of representing a cell. A short heavy line represents the negative terminal and a longer lighter line the positive terminal.

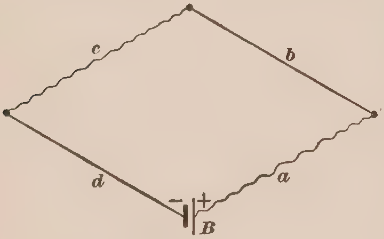


FIG. 4

29. Parallel, or Multiple, Connections.—A circuit that is divided into two or more branches, each branch carrying part of the current, is a parallel, multiple, shunt, or divided circuit, and the separate branches are connected in parallel, in multiple, or in shunt. Fig. 5 shows a divided circuit consisting of a source of electromotive force, *B* and conductors *a, b, c,* and *d*. Conductors *b* and *c* afford two current paths between the conductors *a* and *d*, and are therefore, in parallel. Either path *b* or *c* can be opened without interfering with the flow of electricity through the other path, because each is independent of the other. The arrows indicate direction of current. The total current in a parallel circuit is the sum of the current in the various branches.

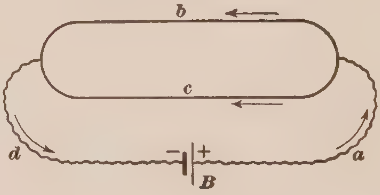


FIG. 5

30. When devices are connected in several series and these series are connected in parallel, as in Fig. 6, the devices are said to be connected in parallel-series, or multiple-series. *Series-parallel connection* means literally a series of parallels, as indicated in Fig. 7, in which three groups *a*, *b*, and *c* are connected in series, each group having four devices in parallel.

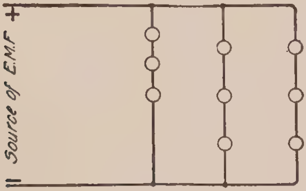


FIG. 6

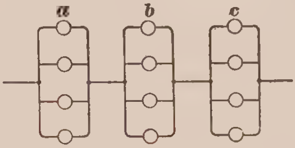
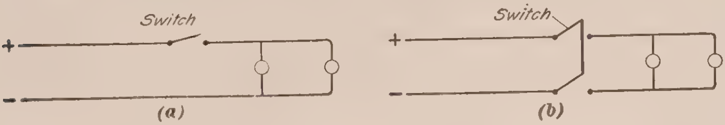


FIG. 7

The small circles of Figs. 6 and 7 represent the customary way among electricians of indicating filament lamps, such as Mazda lamps, in wiring diagrams.

31. Switch.—A switch is a device for opening and closing an electric circuit. If it opens or closes the circuit in only one place, as in Fig. 8 (*a*), it is a single-pole switch; if it opens or closes both parts, or sides, of the circuit, as in (*b*), it is a two-pole, or double-pole, switch. In speaking of opening or closing circuits, the trade words *break* and *make* are often used to convey the same meaning. A cut-out is essentially an automatic device that opens a circuit when the current becomes too great.

32. Grounded Circuit.—An electric circuit is said to be grounded when any part of it is either intentionally or accidentally in electrical connection with the earth or with a conductor leading to the earth.



(*a*) (*b*)

FIG. 8

33. Short Circuit.—A short circuit is a path of very low resistance between two points having a difference of potential.

For example, if two bare wires leading to a lamp should become crossed, or touch each other, a short circuit would be formed, and the lamp would be short-circuited.

VOLTAGE DROP AND ENERGY LOSS

34. In an electric circuit the total drop of potential, or *voltage drop,* is equal to the electromotive force necessary to maintain current in the circuit against the various opposing forces in the circuit. For example, imagine a source of electromotive force developing 230 volts supplying current through wires to an electric motor. Some of the electromotive force, say 10 volts, is used in overcoming the resistance of both wires of the circuit, and the remainder, 220 volts, is available at the motor terminals. The voltage drop in the two wires of the circuit is 10, and the drop in the motor is 220.

35. The voltage drop in conductors can be calculated if the length of the wire, the current, and the cross-sectional area of the wire in circular mils are known by using the formula

$$\text{voltage drop} = \frac{10.8 \times l \times I}{a}$$

in which 10.8 = resistance, in ohms per foot, of copper wire one mil in diameter;
l = length of wire, in feet;
I = current, in amperes;
a = cross-sectional area of wire, in circular mils.

36. Voltage drop in conductors leading to electric motors, lamps, and so forth, serves no useful purpose, and, when multiplied by the current and time, equals the energy wasted in heating the conductors. It is, therefore, desirable to make the drop low, not only for economy in transmission, but also to prevent overheating the conductors. In order to keep the voltage drop down, the wires must be of minimum length and of maximum diameter. But the length l is usually fixed by the location and size of the buildings to be wired and the current I is determined by the number and size of the devices to receive current. Furthermore, wires must be selected to comply with the rules of fire-insurance underwriters and with city ordinances. Because of the heating effect of the electric current and the resulting fire hazard, insurance underwriters and many cities have prescribed rules limiting the quantity of current in each standard size of wire.

37. The engineer must provide himself with a copy of the National Electrical Code of Rules, which can be obtained through any general insurance agency, and a copy of the ordinances of his city. Having determined the current to be carried, he must then select wires no smaller than are called for by these rules and check the sizes by the formula of Art. **35** so as to be sure that the voltage drop is not greater than the difference between the voltage at the source of the electromotive force and the voltage required at the terminals of the lamps or motors to be fed. The calculation may show the need of selecting a conductor larger than is prescribed by the rules, and this is often the case for long circuits.

PRIMARY MAGNETIC DEFINITIONS

38. In Magnesia, a province of ancient Greece, a substance was found many years ago that had the peculiar property of attracting to itself pieces of iron. The name of the province suggested the name *magnet* for the substance and later the discovery was made that pieces of steel can be *magnetized* so that they exhibit the same peculiarity. The names *natural magnets* and *artificial magnets,* therefore, came into use. Natural magnets are very rare and are of no practical use, but artificial magnets are an important part of many electrical devices.

Materials capable of being magnetized are magnetic, and, of these, iron and steel are most important. Soft iron when brought close to a magnet is magnetized temporarily, but loses its magnetism when the two are separated. Steel, however, when magnetized, retains its magnetism, and thus becomes a permanent magnet.

In every magnet are two points, called *poles,* that exhibit opposing characteristics. For example, in a magnetized steel bar, or *bar magnets,* the poles are at the ends, and if two such magnets are brought near each other, one pole of one magnet will either attract or repel one pole of the second magnet, but will have exactly the opposite effect on the other pole.

39. Around every magnet is a space, or field, called the *magnetic field,* within which the magnet exhibits its power to attract or repel. Any piece of magnetic material, such as iron or steel, when in a magnetic field, becomes a magnet with poles in opposite positions from those of the magnet causing the field. In other words, magnetism is induced in such material, and this magnetism has direction, or is along certain lines called *lines of force.* All the lines of force of a magnet combined are called the *flux* of the magnet, or the *magnetic flux.*

Magnetic lines of force pass out of the north pole of the magnet and enter the south pole, passing through the magnet itself from the south pole to the north pole. A point near the north geographical pole is called a north magnetic pole, but, in reality, if the magnetic rules are applied to the earth's magnetic pole, the magnetic pole situated near the north geographical pole would be known as a south magnetic pole, and the magnetic pole situated near the south geographical pole, a north magnetic pole. Since the lines of force pass through a magnet from the south pole to the north pole, the lines of the earth's magnetic field would pass from near the north geographical pole, through the earth, to a point near the south geographical pole, from there out through the atmosphere to the magnetic pole near the north geographical pole. Any magnet that is placed in line with a magnetic field will turn so as to have the magnetic lines pass into its south pole, and out of its north pole, the magnetic lines passing through the steel of the magnet itself from the south magnetic pole to the north magnetic pole. The north pole of the compass needle, or the north-seeking pole, points toward the magnetic pole situated near the north geographical pole.

40. Every conductor carrying an electric current is surrounded by a magnetic field. The effects of this field are maximum in the space next to the conductor, the effects decreasing as the distance from the conductor increases. The magnetism thus established by an electric current is called *electromagnetism.*

GENERATORS AND MOTORS

41. Electromagnetic Induction.—Electromagnetic induction is the action by which an electromotive force is established in a conductor by the influence of a magnetic flux. If a conductor be moved in a magnetic field so as to cut across the lines of force, an electromotive force will be set up in the conductor, and, if the conductor be part of a closed circuit, an electric current will flow in it. The same effect will be produced if the conductor be held stationary and the magnetic field be in motion; it is only necessary that there be between the two relative

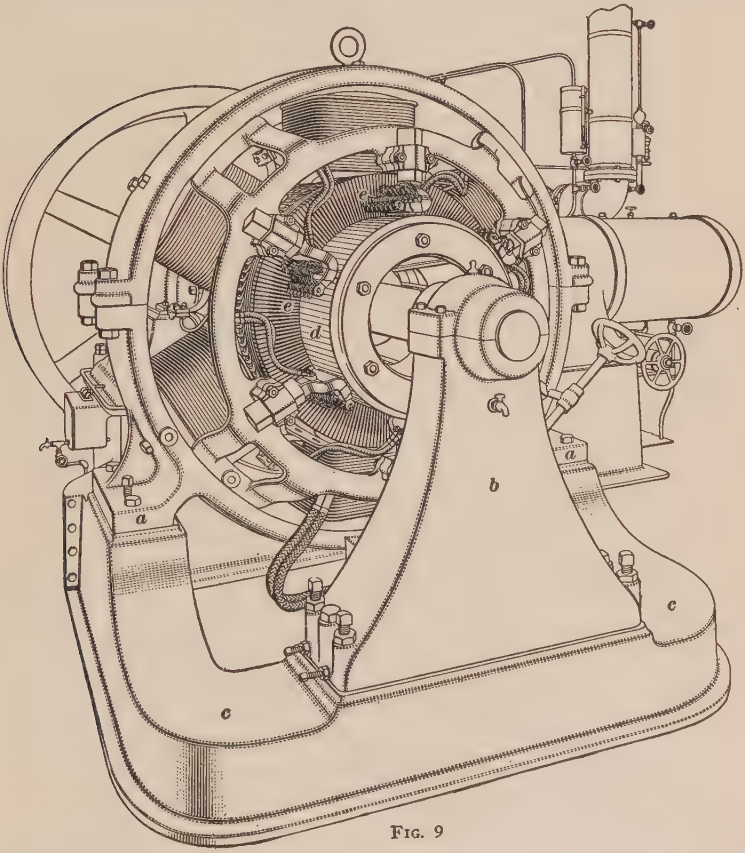


FIG. 9

motion such that lines of force are cut by the conductor. The direction of the induced electromotive force depends on the direction of the lines of force, or polarity of the magnetic field, and on the direction of motion; a reversal of either polarity or motion reverses the electromotive force.

42. Electric Generator.—The principle of electromagnetic induction is used in the electric generator, which is a machine for converting mechanical work into electrical work. A direct-current generator, which, as the name implies, is a machine for developing direct-current electricity, has a stationary field magnet and a revolving armature that carries the conductors in which the electromotive force of the machine is generated. In revolving, each conductor on the armature passes under a north pole and a south pole alternately. The direction of electromotive force therefore alternates, and, in order that a direct current may be delivered, a device called a *commutator* is necessary. Current is collected from the revolving armature by stationary brushes bearing on the commutator. The commutator and the brushes are so arranged that the connection of the external circuit to the armature conductors is reversed at each instant that the current in the conductors reverses, so that each brush collects current passing in only one direction.

43. In Fig. 9 is shown a direct-current generator connected directly to a reciprocating steam engine; *a* indicates the feet of the generating frame, *b* the bearing pedestal, *c* the bedplate, *d* the commutator, and *e* the armature. The word *dynamo* is sometimes used in referring to a direct-current generator.

44. Direct-current motors are the same in elementary respects as direct-current generators, but they differ in mechanical design because they are required to perform a different service. Properly timed attractions and repulsions between the field magnet and the armature cause the rotation.

ELEMENTARY ALTERNATING-CURRENT DEFINITIONS

45. Principle of Alternating-Current Generator.—Because the armature conductors of a generator pass a north pole and a south pole alternately, the electromotive force generated therein is alternating. If the commutator of a direct-current generator be replaced by a pair of rings insulated from everything except the circuits of which they are parts, the electromotive force between the rings will be alternating, and a current in an external circuit connected to the rings through brushes will also be alternating. This is the principle of the alternating-current generator, more frequently called an *alternator*.

46. Generator Comparison.—A primary difference between an alternator and a direct-current generator is that the former needs no commutator. The alternating current of the armature winding can pass directly to the external circuit, and, therefore, the armature can be made the stationary member of the machine. In fact, most alternators are constructed with the armature the stationary member, or *stator,* and the field magnet the rotating member or *rotor*.

47. The electromotive force generated by an alternator —in other words, an alternating electromotive force—rises from zero to a maximum value in what is arbitrarily called a positive direction, falls to zero, rises to a negative maximum, falls to zero again, and so on repeatedly, as long as the alternator is in operation. There is a continually recurring set of values, half positive and half negative, and one such set is called a *cycle*. An alternation is one-half cycle; conversely, a cycle is two alternations. The number of cycles per second is called the *frequency*.

POLYPHASE ALTERNATING CURRENTS

48. Single-Phase System.—If an alternator has only one armature winding, all the armature conductors act together to set up one electromotive force and one current, called a *single-phase electromotive force* or a *single-phase current,* respectively. The circuit that carries the current is called a *single-phase cir-*

cuit and the alternator is called a *single-phase alternator.* Such an alternator is said to have a single-phase winding. But it is possible to equip an alternator armature with two or more windings with the conductors so arranged that the electromotive forces and the resulting currents have definite phase relations with one another. The winding, the alternator, the electromotive forces, the currents, and the circuits are then designated as *polyphase,* and each is a part of a polyphase system.

49. Polyphase System.—Fundamentally, a polyphase system is a number of single-phase systems properly combined. The polyphase system may have a pair of conductors for each single-phase element; or some of the conductors may be omitted and those remaining may be made to act in common for all the single-phase elements. The current in any of these common conductors is not equal to the arithmetical sum of the single-phase current, but is less, because of the phase differences among the currents.

50. The only two commercial polyphase systems of practical importance are the *two-phase system* and the *three-phase system.* In the former the alternator windings are arranged so that two currents are established which are one-fourth of a cycle apart in phase. Usually four wires are employed in the external circuit, so that the system is practically equivalent to two single-phase systems employing two wires each. In the three-phase system, the alternator windings are arranged so that three currents are established which are one-third of a cycle apart in phase.

ALTERNATING-CURRENT MACHINERY

51. Classification.—Alternating-current motors are divided into two broad classes, *single-phase motors* and *polyphase motors,* depending on whether they operate on single-phase current or on polyphase current.

52. Induction Motor.—An induction motor has a stator, or stationary member, sometimes called the *primary*; and a rotor, or revolving member, sometimes called the *secondary.* The speed of an induction motor can be controlled with the aid of extra devices, but usually the motor runs at nearly constant speed under ordinary load conditions. It also can be made to start under load. Induction motors are made in sizes and designs adaptable to almost every kind of machine requiring mechanical drive. One of the many types of three-phase motors is shown in Fig. 10. There is a limit, however, to the sizes in which single-phase motors can be made.

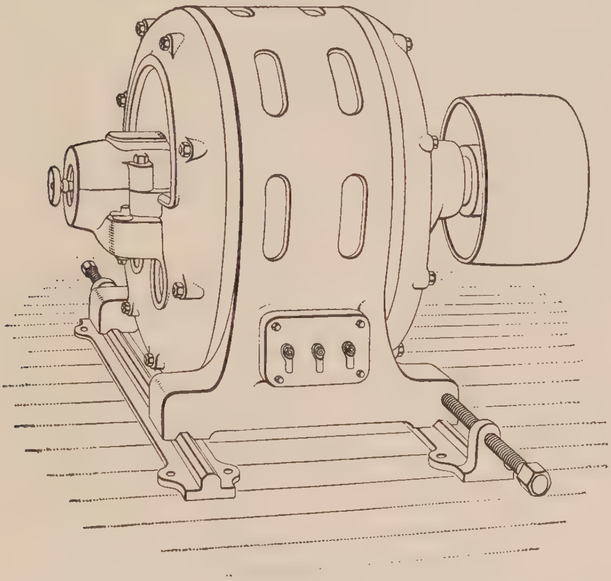


Fig. 10

53. Transformers.—A transformer, sometimes called a *static transformer* because it has no moving parts, is a device for changing the voltage of alternating current circuits. A *step-up transformer* raises the voltage, and a *step-down transformer* lowers the voltage. Each transformer has two coils, both on the same iron core. Each coil is insulated from the other and from the core. The primary coil is the one that takes the current from a supply circuit, and the secondary coil is the one that supplies current to some other circuit or devices. One is a low-voltage coil and the other a high-voltage coil. For economical transmission of electric energy over long distances the voltage must be high, and step-up transformers are generally used to raise it; from such a high-voltage system the voltage must again be stepped down by other transformers to the voltage permissible for interior wiring. The external appearance of a transformer is shown in Fig. 11. A bank of transformers is a combination of transformers connected together in place of a single large transformer.

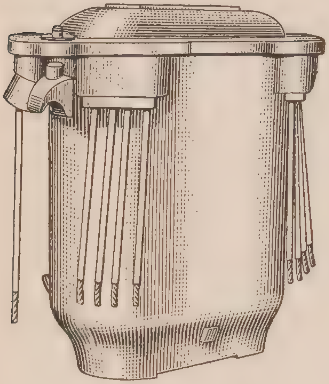


Fig. 11

54. A **rectifier** is, in general, any device for changing alternating current to direct current. One form is the mercury-vapor rectifier, so called because it utilizes a peculiar property of mercury in changing the current. The Tungar rectifier is used extensively for charging storage batteries for automobiles and signaling systems.

MISCELLANEOUS DEFINITIONS

55. The **load** on an electric generator, a battery, or on an electric system in general, usually means the power taken from the system, although the term is sometimes applied to current. An **overload** is a load that is greater than the system is designed to handle.

56. A **storage cell** is a device for converting electrical work into potential chemical energy, and holding it available for return as electrical work. A storage battery is a combination of storage cells.

57. A **motor-generator** is a generator driven by a motor. The generator and the motor are usually mounted on the same bed-plate, and both of the rotors are on the same shaft. Motor-generators are used for converting alternating current into direct current, or vice versa, and for changing the voltage of direct current.

58. A **switchboard** is a place for mounting switches and other devices required for controlling a number of electric circuits. The switchboard usually bears the proper measuring instruments also. The switchboard is the heart of the control system of a large interior wiring installation. There the entire

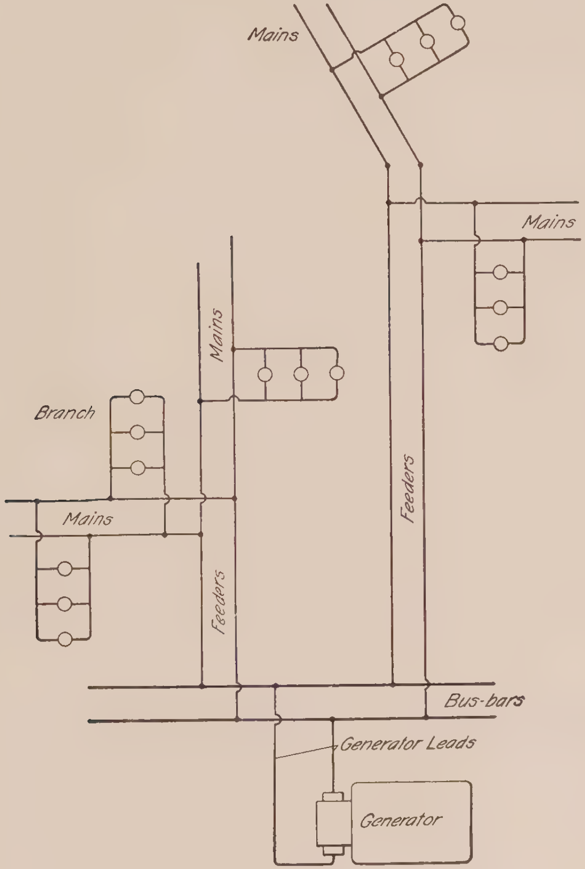


FIG. 12

system, or any part of it, can be disconnected from the source of electrical supply.

59. A **bus-bar,** or **bus,** on a switchboard is a conductor mounted on the back of the board, and so connected with switches that by operating a switch any one or more of several circuits may be connected to the bus-bar or disconnected from it at will. Usually at least two bus-bars are required for the ordinary interior circuit.

60. A **feeder** is a part of a system that carries current for a number of other circuits or parts of the system. A feeder serves as a trunk. A **main** is practically a continuation of a feeder, but carries less current and is made up of smaller conductors. A **feeder-and-main system** is similar to a tree, and is sometimes called a tree system; the feeder is the trunk, the mains are the branches, and the small circuits, or branch circuits, correspond to the twigs of the tree.

61. In Fig. 12 are illustrated the main essentials of a distributing system for electricity. The diagram shows the fundamental relations of bus-bars, feeders, mains, and branch circuits. The illustration also shows one of the conventional methods of representing direct-current generators or motors on wiring diagrams.

62. A **relay** is a device for closing or opening an electric circuit, as the case may require, when predetermined conditions in another circuit take place.

63. A **magneto** is a small alternating-current generator with a field formed of permanent magnets, and a rotating armature with a large number of turns of fine wire. A magneto is used chiefly for testing and in telephone systems.

NATIONAL ELECTRICAL CODE

64. Origin and Purpose.—When electricity began to come into general use, electric wiring in buildings was installed with little regard to safety, and many disastrous fires resulted. Soon fire underwriters refused to insure buildings unless the wiring was considered safe, and the preparation of a set of safety standards became necessary. In 1897 a national conference of delegates representing various insurance, electrical, architectural, and allied interests in the United States proposed the National Electrical Code, which was at once adopted by the National Board of Fire Underwriters. The Code is now in charge of the National Fire Protection Association and is accepted as standard not only by underwriters but by many state and municipal governments and by various organizations of public service corporations, professions, manufacturers, and trades interested in the design or the construction of buildings.

The Underwriters' Laboratories located in New York and Chicago test the various materials and devices that are used in electrical construction, and they also publish a "List of Inspected Electrical Appliances" which they have found by tests to comply with the standards of the Code.

65. Special Rules.—In many of the large cities, the installation of the electric wiring is governed by municipal ordinances. The Electrical Service Companies also have rules that must be observed before they are permitted to make connections to the supply mains.

66. Inspections.—Each local board of fire underwriters has inspectors who examine and test the electrical work of buildings at certain stages of its progress and also after the building has been completed, to determine if the rules of the code have been complied with. A certificate of approval is issued by the underwriter when the completed work is found to meet these requirements. Where municipal ordinances are in force, the work must be installed to conform with these requirements and a certificate is issued by the city when the work has been approved.

67. Advantages of Code.—The National Electrical Code and the List of Inspected Electrical Appliances provide standards by which architects and contractors can plan and execute work that will meet the requirements of the Underwriters when insurance is desired. For buildings on which no insurance is contemplated, it will also prove a practical and reasonable investment to have the work installed in conformity with these standards, as it will greatly reduce the fire hazard. It is, therefore, very important that the architect and contractor be thoroughly familiar with both the Code and the List of Inspected Electrical Appliances and install work that will conform with these requirements. Copies of the Code and the List of Inspected Electrical Appliances may be obtained from any local office of the Underwriters, or from the New York or Chicago Underwriters' Laboratories.

68. If the building is located in a city, inquiry should be made to learn the requirements of the municipal ordinances and the company furnishing the electrical power. Architect's specifications usually stipulate that all electrical work and materials shall conform with the code standards and the city ordinances, and that certificates of approval shall be obtained from the underwriters and the city before the final payment is made to the electrical contractor. The inspection and approval of the electrical work by persons familiar with all details of electrical installation are evidence of a good job and are essential to the obtaining of the minimum rate for insurance, should the owner desire to insure the building.

WIRING FOR LIGHT AND POWER

DISTRIBUTION SYSTEMS

FUNDAMENTAL SYSTEMS

69. An electrical-distribution system comprises all the conductors and all the apparatus necessary to take electricity from a source of supply and deliver it in proper form for utilization at various electrical devices. Practically all distribution systems for interior wiring are parallel systems; the conductors and the apparatus are connected in parallel.

70. The two fundamental systems are the direct-current system and the alternating-current system. They are also classified as low-tension systems and high-tension systems, depending on the voltage of distribution. From the architect's viewpoint, a complete distribution system can be divided into two parts, the outside system, by which electricity is brought to a building, and the interior system, by which it is distributed throughout the building. Practically all American systems are constant-potential systems, so called because the voltage at the consuming device remains practically constant.

71. Constant-potential systems of 600 volts or less are classed by the underwriters as low-potential systems, those of 601 to 5,000 volts, as high-potential systems; and those of over 5,000 volts as extra-high-potential systems. As a general rule, voltages above 250 are seldom used in buildings other than those of an industrial character. Where high voltage is used, however, the apparatus should be enclosed by means of a wire screen or a railing, to provide ample protection against a person accidentally coming in contact with the devices and being seriously injured.

72. Direct-current systems employ either two or three wires as conductors, and are know as *two-wire systems* and *three-wire systems,* respectively, as shown in Figs. 13 and 14.

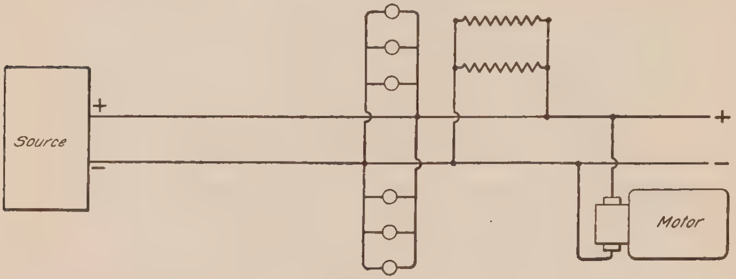


FIG. 13

The neutral wire of a three-wire system is usually placed in the center and the pressure between this wire and either outside wire is one-half the pressure between the outside wires. In diagrams the neutral wire is generally indicated by the ± sign, as shown.

73. Several alternating-current systems are in use for interior wiring, namely, the single-phase two-wire system for which the diagram is the same as for the direct-current two-wire system, Fig. 13; the single-phase three-wire system with connections as shown in Fig. 14; the two-phase four-wire system, Fig. 15, which is practically equivalent to two single-phase two-wire systems; the two-phase, three-wire system, Fig. 16; the three-phase,

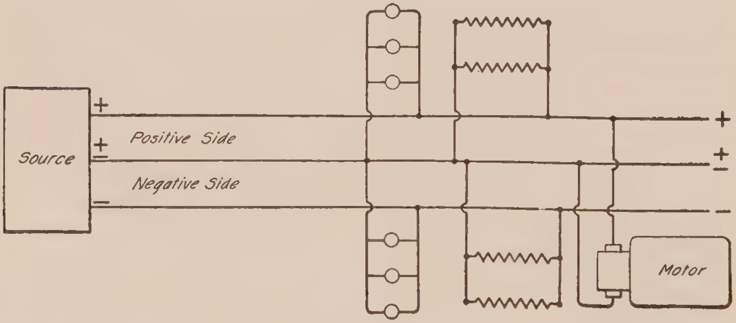


FIG. 14

three-wire system, Fig. 17, and the three-phase four-wire system, Fig. 18.

A simple three-phase system would have six wires, two for each phase, if it were not for the time-phase relations of the voltages and currents, which permit one wire of each phase to be eliminated, each of the three remaining wires acting in turn as the second wire for each of the other two phases.

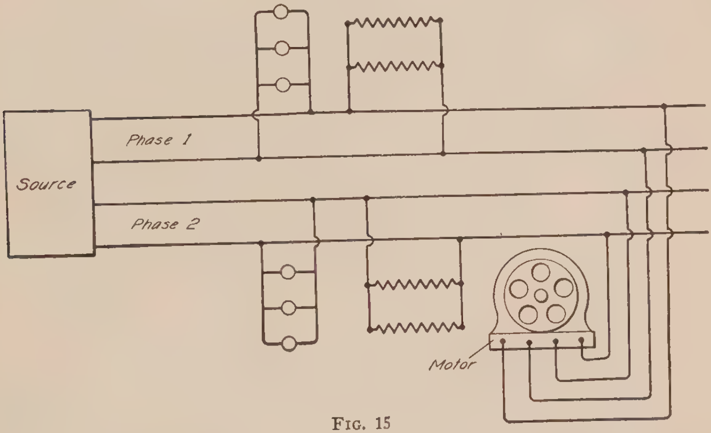


FIG. 15

74. The three-phase, three-wire system illustrated in Fig. 17 is the result of such an arrangement. A two-wire circuit can be connected across any two wires of the system. A

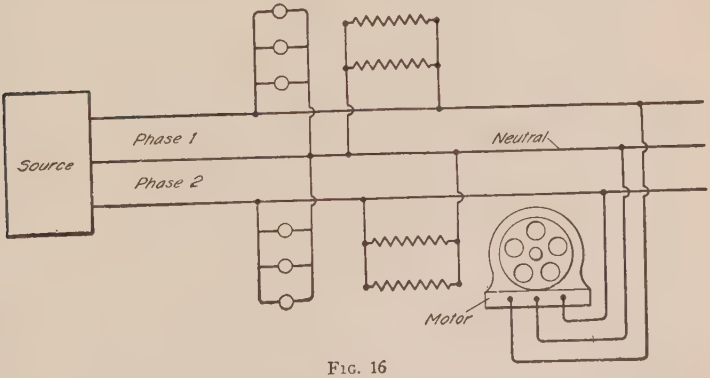


FIG. 16

two-wire circuit is then, in effect, a single-phase alternating-current system deriving its energy from the three-phase system.

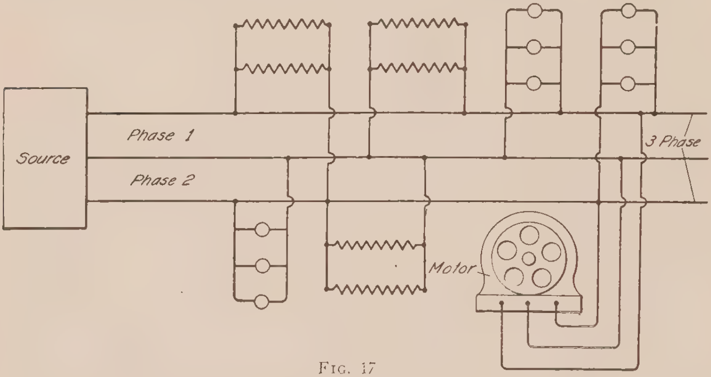


FIG. 17

Single-phase circuits thus tapped from the three-phase system are connected so as to keep the three-phase system as nearly as possible in balance. Three-phase motors use all the wires of the system, as indicated in the diagram.

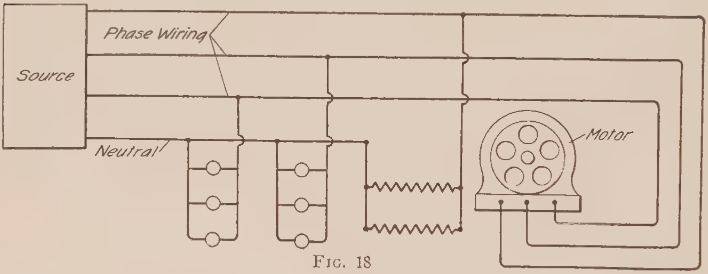


FIG. 18

COMMERCIAL SYSTEMS

75. Choice Between Direct and Alternating Current.—Any installation of interior wiring must be planned according to the kind of electricity available in the locality. If the energy is to be taken from lines of the local light and power company, as is generally the case, the characteristics of the current can be learned from that company.

76. Direct-Current Energy.—If the designer is free to choose the kind of energy, he must decide first between direct-current and alternating current. This is a problem which should be referred to an electrical engineer if the work is extensive or the requirements complex. For general information, however, it is desirable to know that direct-current energy is essential for some purposes such as storage batteries, electrolytic work, and operating some kinds of lamps. It is also preferable to alternating current for operating motors on hoists, cranes, or other machinery.

77. Alternating-Current Energy.—For motors that must run at very nearly constant speed under all conditions of load and temperature, as in driving textile machinery, alternating-current energy is essential. This requirement may demand such energy, even though the distribution covers a very small area. If such energy is purchased, the following information should be obtained from the central station: System of inside wiring recommended, number of phases, and number of wires; service voltage, or voltage at which current will enter the building; manner in which company's wires will enter building, overhead or underground; location of transformers.

78. When installing a private generating plant, there is opportunity to choose an alternating-current system best adapted for the purpose to be carried out. The single-phase system affords the simplest form of alternating-current distribution, and is much used, especially where the load is composed either entirely or very largely of lamps. Many single-phase motors are in use in capacities up to 10 horsepower, inclusive, and are practically equal to polyphase motors in starting and operating characteristics, although some complications in construction are necessary in order to obtain good starting effort.

79. Two-phase systems are not so commonly employed as three-phase systems. The three-wire three-phase system is particularly applicable where the amount of lighting is small compared with the amount of motive power used. Single-phase lighting from three-wire three-phase mains is unsatisfactory when many lamps are in use, unless the load is so carefully balanced that the voltage regulation will not be disturbed. The four-wire three-phase system is better where both lamps and motors are in use, because the voltage regulation is better.

FEEDER-AND-MAIN SYSTEM

80. Service Mains.—When electricity is purchased from a light and power company, service leads, or service mains, leading to the consumer's premises are installed by the central-station men to carry current from the central-station distribution system to the interior wiring of the building, as indicated in Fig. 19, which shows the service connections for a two-wire installation in a small residence. In practice, the switch and the cut-out, consisting in this case of fuses *a* mounted on a porcelain base *b*, are customarily placed in a metal box or cabinet *c*, with a handle on the outside of the box, as shown by the

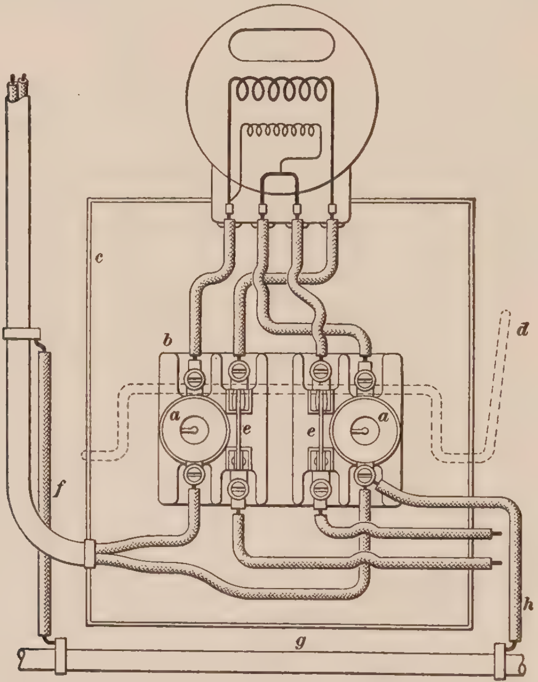
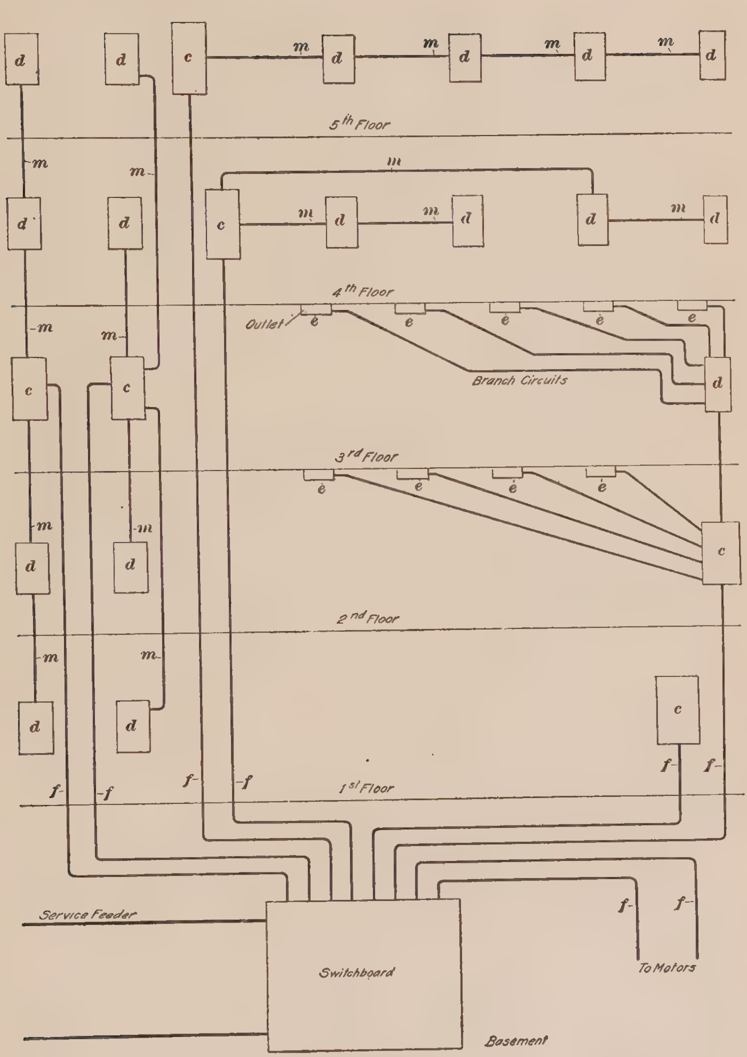


FIG. 19


d
d
c
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5th Floor
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4th Floor
Outlet
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-m
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c
Branch Circuits
d
3rd Floor
e
e
e
e
-m
-m
d
d
c
2nd Floor
-m
m
d
d
c
f
f
f
-f
-f
f
1st Floor
Service Feeder
Switchboard
f
f
To Motors
Basement

FIG. 20

dotted lines *d*, to operate the switch blades *e*. The service conduit is grounded at *f* to a water pipe *g*, and one side of the circuit is grounded through *h* to the same pipe.

81. Purpose of System.—The feeder-and-main system is almost invariably followed in wiring large installations, and is applicable to either direct- or alternating-current systems. The service feeder from the outside distribution system is carried to a switchboard, Fig. 20, on which are mounted the central-station company's meters and the service switches. This switchboard serves as the main center of distribution for the building. From the switchboard, trunk conductors, or feeders shown at *f* are carried to distribution centers *c*, from which smaller trunks, or mains *m* run to other distribution centers *d*, and from these are carried the branch circuits *e* to which the electrical appliances are connected. If the wiring is concealed, the appliances are connected at outlets, the points at which the wiring is brought to the surface. From some distribution centers, both mains and branch circuits may be run, as shown at the right in the illustration, while some feeders may supply branch circuits only, as conditions may require. Large motors require separate feeders. A vertical feeder or main is called a *riser*.

The layout shown is not intended to represent an actual installation. It is designed chiefly to show the different methods of connecting circuits. In this layout branch circuits are shown from only two of the distributing centers, but in the actual installation branches are taken from each center.

WIRES AND CABLES

TERMINOLOGY

82. A **wire** is defined by the U. S. Bureau of Standards as a slender rod or filament of drawn metal. An **insulated wire** is one covered with an insulating material. A **stranded conductor** is one composed of a group of wires, or any combination of groups of wires. The word *strand*, as commonly used, may refer to one of the wires or to one of the groups of wires making up the conductor of a cable.

The word *cable* is usually applied to the larger conductors, especially if stranded, while the smaller conductors are known as *wires* or *cords*.

Single-conductor cable is the name usually given to a cable consisting of one stranded conductor. A *multiple-conductor cable* is a combination of conductors insulated from one another. *Duplex cable* is frequently called *two-conductor,* or *two-wire, cable; triplex cable* is called *three-conductor,* or *three-wire cable.*

A duplex cable is a cable composed of two stranded conductors twisted together, and should be distinguished from a *twin cable,* which consists of two insulated stranded conductors laid parallel in a common covering. The duplex cable is a convenient and much-used form of cable.

Cord, commonly called *flexible cord,* is the name generally applied to a small, very flexible, insulated cable designed to withstand wear well.

A **twisted pair** consists of two small insulated conductors twisted together, without a common covering.

Twin or **duplex wire** is made up of two small insulated conductors laid in parallel in a common covering.

83. As indicated by the foregoing definitions, wire terminology is employed somewhat loosely because of the large variety of wires and cables necessary to meet so many applications. If an electrician needs to be explicit in mentioning a large-size conductor, if he means a solid conductor, he says (referring to a wire-gauge number) *number two-nought wire,* or, if he means a stranded conductor, *number two-nought cable.* In mentioning a smaller size, he says *number ten wire* or *number ten stranded,* as the case may require. In this Section the word *wire* when used in the collective sense or in the plural is understood to include all conductors, either wires or cables, and their insulation.

WIRE UNITS AND GAUGES

84. Mil.—The unit commonly employed to measure the diameters of wires for electric conductors is the mil, equal to .001 inch. The unit or area is the circular mil, the area of a circle with a diameter of one mil.

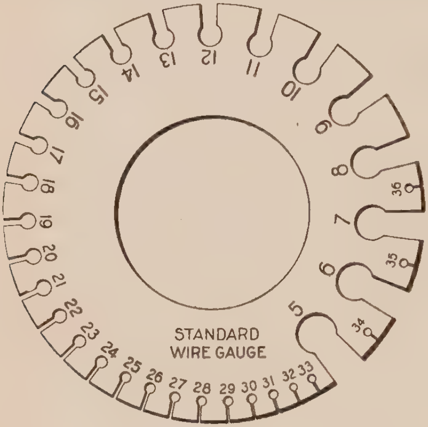


FIG. 21

85. Diameter of Wires.—Wires for commercial use are made with certain standard diameters, each diameter usually being specified by a gauge number. Of the several systems of gauge numbers used in the United States the most common is the American, or Brown and Sharpe (usually written B.&S.). The largest wire with a B. & S. gauge number is 0000 (pronounced *four nought* and frequently written 4/0), having a cross-sectional area of 211,600 circular mils. Larger conductors are designated by giving their areas in circular mils. In either case the dimensions are for the bare conductor only, the covering not being included. The size of a solid conductor, or wire, is most conveniently measured by means of a wire gauge,

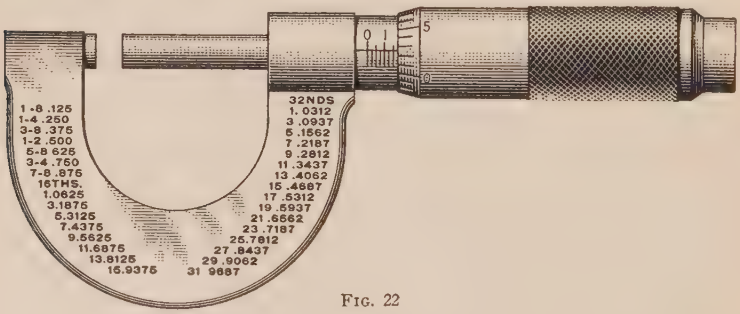


FIG. 22

one form of which is shown in Fig. 21. To measure accurately the diameter of a stranded conductor, or cable, a micrometer caliper, Fig. 22, is necessary. Although aluminum has been used to some extent, refined copper of the highest obtainable commercial conductivity is almost always employed for conductors installed in buildings.

INSULATION

86. Rubber-covered (R.C.) wire or cable has an insulation of rubber compound of approved thickness covered by one or two outer protective braids. Conductors with slow-burning weather-proof (SBW) insulation have a single braid impregnated with a water-resisting material next to the conductor and one or two outer braids impregnated with a fire-resisting material. Slow-burning (SB) insulation consists of three or more braids impregnated with fireproofing material, the outside braid being specially designed to withstand abrasion.

Weather-proof (WP or Wp) insulation consists of at least three braids, all saturated with a moisture-proof insulating compound. Weather-proof wire is for use outdoors, where moisture is certain and where fireproof qualities are not necessary.

The insulation and the protective covering of flexible cord depends on the use to which the cord is to be put, and the specifications are fully covered by the Code.

Fixture wire is for use for inside electric fixtures, and may be either approved cord or approved rubber-covered wire, except where the wire may be subjected to a temperature higher than ordinary.

87. Lead-covered wires or cables are rubber-covered conductors having, in addition to the usual insulation and protection, a continuous lead sheath. Other names in frequent use are *lead cable* and *leaded wire*. The sheath of metallic lead is employed to give added protection from abrasion and moisture in places such as underground ducts. The lead also serves to protect the insulation from the action of chemical fumes, and is, therefore, useful in many industrial plants.

WIRE TABLES

88. Information that will be helpful in the selection of conductors for interior wiring is given in Tables I and II, the first table listing flexible cords in common use and the second giving the carrying capacities of standard conductors. Amperages greater than those listed in Table II are not considered safe, as the heating effect will cause the rubber insulation to deteriorate. For this reason, a lower current is specified for a conductor having rubber insulation than for one of the same size which has greater heat-resisting properties. Rubber-covered wire is generally used for interior work.

89. Sizes of Wires.—The smallest wire of the B. & S. system is No. 40, with a diameter of 3.145 mils; but wires smaller than No. 18 are not permitted in interior wiring, except as strands. The Nos. 16 and 18 wires are permitted in cords and in fixture wiring; other wires must not be smaller than No. 14. Solid conductors as large as No. 8 may be used, but for conduit work conductors of this size and larger are more easily handled if stranded. The size of the strands depends on the size of the conductor and the conditions under which it is to be used. Some engineers require that no conductor smaller than No. 14 shall be used on a job, even in fixtures; that no conductors smaller than No. 12 shall be used for other work; and that all conductors larger than No. 10 shall be stranded.

90. Inspection of Wire.—Approved wire bears the inspection stamps of the Underwriters' Laboratories and usually has a system of colored threads woven into the braided covering to identify the wire and also serve as a manufacturer's trade-mark.

TABLE I

FLEXIBLE CORDS

Use	Type	Trade-Name	Branch on Each Conductor	Reinforcement or Filler	Outer Cover
As pendents or portables in dry places.........					
Where not subject to hard usage	*C* *PD* *PO*	Lamp cord Twisted portable Parallel cord	Cotton or silk Cotton or silk Cotton or silk		Cotton or Silk Cotton or Silk
For Hard Usage........	*P* *CA* *PA*	Reinforced cord Armored cord Armor reinforced cord	Cotton or silk Cotton or silk Cotton or silk	Rubber Jacket Rubber Jacket	Cotton or Silk armor Cotton and armor
Pendents damp places...	*CB* *CC*	Brewery-cord Canvasite cord	Cotton Wp. Cotton Wp.		Cotton Wp.
Portable damp places....	*P Wp.* *Pk Wp.* *PA Wp.*	Reinforced cord Wp. Packinghouse cord Armor reinforced cord Wp.	Cotton Cotton Cotton	Rubber Jacket Filler Rubber Jacket	Cotton Wp. 2 Cotton, both Wp. Cotton Wp. and armor
Theatre Stages	*T*	Stage cable	Cotton Wp.	Filler	2 Cotton, both Wp.
Theatre Borders	*B*	Border light cable	Cotton Wp.		2 Cotton, both Wp.
Elevator Lighting and control	*E*	Elevator cable	Cotton	Rubber Jacket and or	1 or more cotton both Wp. 3 Cotton, outer one Wp.

TABLE II

CARRYING CAPACITIES OF INSULATED WIRES

B. & S. Gauge Number	Sectional Area Circular Mils	Rubber Insulation Amperes	Other Insulations Amperes
18	1,624	3	5
16	2,583	6	10
14	4,107	15	20
12	6,530	20	25
10	10,380	25	30
8	16,510	35	50
6	26,250	50	70
5	33,100	55	80
4	41,740	70	90
3	52,630	80	100
2	66,370	90	125
1	83,690	100	150
0	105,500	125	200
00	133,100	150	225
000	167,800	175	275
0000	211,600	225	325
	200,000	200	300
	300,000	275	400
	400,000	325	500
	500,000	400	600
	600,000	450	680
	700,000	500	760
	800,000	550	840
	900,000	600	920
	1,000,000	650	1,000
	1,100,000	690	1,080
	1,200,000	730	1,150
	1,300,000	770	1,220
	1,400,000	810	1,290
	1,500,000	850	1,360
	1,600,000	890	1,430
	1,700,000	930	1,490
	1,800,000	970	1,550
	1,900,000	1,010	1,610
	2,000,000	1,050	1,670

CUT-OUTS AND SWITCHES

CUT-OUTS

91. Fuses.—In order to protect conductors from overload, short circuits, grounds, and so forth, it is necessary to place at proper locations in a circuit an automatic cut-out, which is a device for opening the circuit when the current exceeds the normal value. A cut-out may be either a fuse or a circuit breaker.

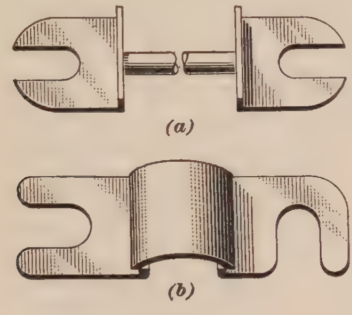


FIG. 23

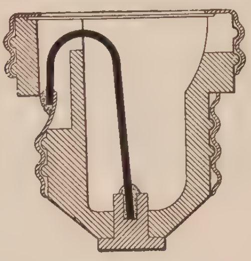


FIG. 24

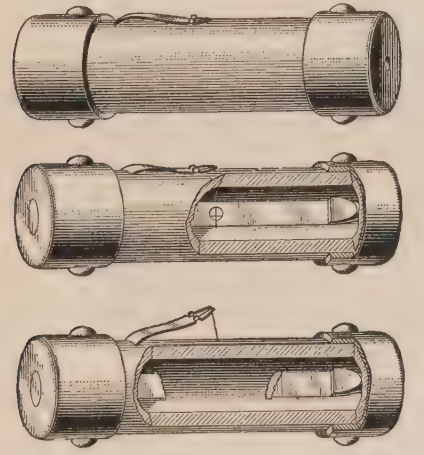


FIG. 25

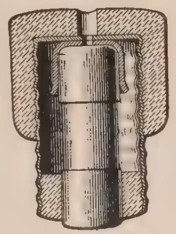


FIG. 26

A **fuse** consists of a wire or a strip of alloy fusible at a comparatively low temperature, with copper terminals. An exces-

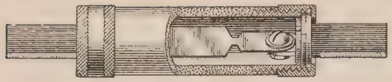


FIG. 27

sive current melts the fusible metal before the remainder of the circuit can be injured. A fuse so treated is said to be *blown*. The simplest form is the *link fuse*, two forms of which are shown in Fig. 23 (*a*) and (*b*).

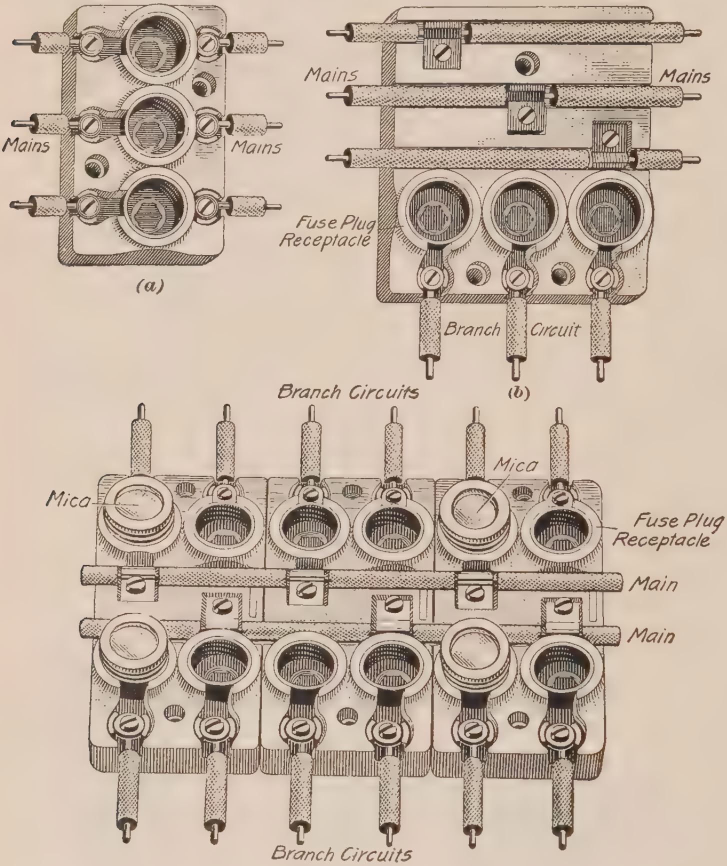


FIG. 28

A *plug fuse*, shown in section in Fig. 24, is made to screw into a receptacle in a manner similar to the ordinary electric lamp.

An example of the *enclosed fuse* known as the *cartridge fuse* is shown in Fig. 25. In Fig. 26 is shown an Edison plug adapted to a cartridge fuse.

A renewable fuse is a cartridge fuse in which the fusible metal strip can be replaced and the holder retained, as shown in Fig. 27.

Open, or link, fuses, have the great disadvantage that they cause an electric arc and the spattering of molten metal when they blow, so they are rapidly becoming obsolete.

Plug fuses are usually mounted on porcelain fuse blocks, three forms of which are illustrated in Fig. 28, (*a*), (*b*), and (*c*). Cartridge fuses also are sometimes mounted on open-fuse blocks. Fuse blocks are generally used for open wiring and for only the cheaper methods of concealed wiring.

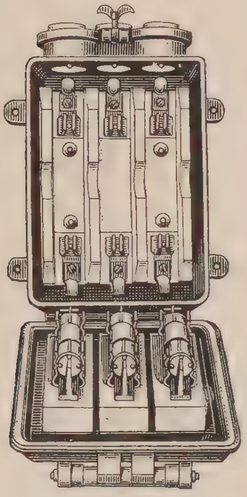


FIG. 29

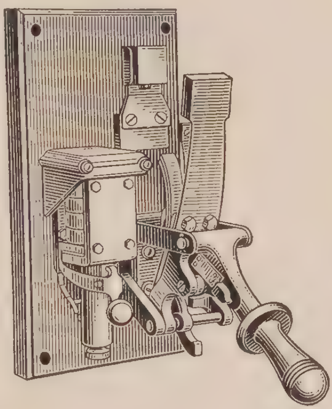


FIG. 30

92. In Fig. 29 cartridge fuses are shown mounted on porcelain blocks, or bases, in a steel fuse box. The fuse terminals are arranged so that by opening the box the circuit is opened, thus preventing danger from shock when replacing a blown fuse.

93. Circuit-Breakers.—Automatic circuit-breakers, one form of which is shown in Fig. 30, are electro-mechanical devices designed to perform the same offices as fuses. In principle a circuit-breaker is simply a special type of switch that can be opened either by hand or by the action of a current greater than that for which the breaker is set. They are used where heavy currents or high potentials are to be handled, as in power plants and industrial works, and on main switchboards in large buildings.

KNIFE SWITCHES

94. A knife switch is so called from the form of the contact-making arm, or blade, and the methods of making contact. A typical form of double-pole knife switch is shown in Fig. 31, and a triple-pole knife switch in Fig. 32. Such switches are commonly called *fused switches,* or *combination cut-out switches,* because fuse receptacles, or clips, *a* and *b,* Fig. 31, are mounted on the bases. The clips shown are to hold the cartridge type of fuse. Link fuses may be connected across the terminals *a* and *b*, Fig. 32. A fused switch is convenient and economical of space, because almost invariably cut-outs are required wherever a knife switch is required. The examples illustrated in Figs. 31 and 32 are single-throw switches because they close in only one direction. A double-throw switch is one that closes in either of two directions, as in Fig. 33, thus enabling the operator to connect a given circuit to either of two other circuits, or to connect a set of mains to either of two feeders.

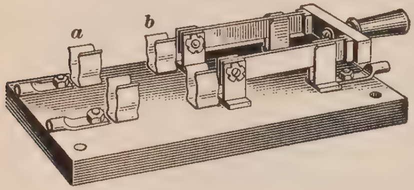


Fig. 31

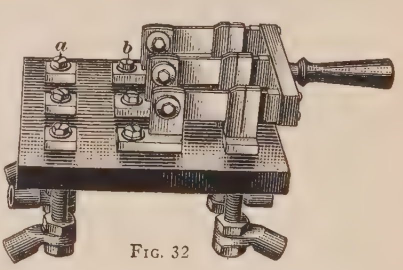


Fig. 32

The switch shown in Fig. 31 is a front-connected switch, as the lugs to which the wires are connected are on the same side of the slate base as the switch lever. Back-connected switches have the connecting lugs on the opposite side of the base, as in Figs. 32 and 33. The switch illustrated in Fig. 33 is shown as it would be mounted on a slate panel of a switchboard. The connecting lugs are shown at *a*. Cartridge fuses are indicated at *b*.

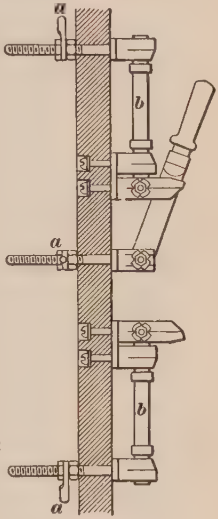
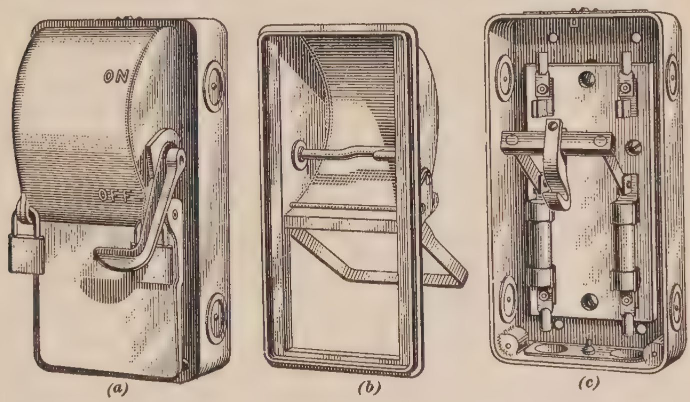


FIG. 33

95. Whenever a current is broken there is formed at the points of break a spark, or arc, the size and intensity of which depends under given conditions on the amperage and the voltage. The underwriters therefore recommend the mounting of individual switches in fireproof cabinets, or switch boxes, one type of which is shown in Fig. 34. In (*a*) is shown the complete box closed and locked. In (*b*) is the cover removed. In (*c*) is the interior of the box. Where wires are carried in metal conduits switch boxes must be made of metal not less than $\frac{3}{32}$ inch thick.

96. A special form of switch and switch box, the so-called *safety-first enclosed lever switch*, is illustrated in Fig. 35 (*a*) and (*b*). The switch blades are operated by a handle that



(*a*) (*b*) (*c*)

FIG. 34

can be moved without opening the box and that can be locked in position. All parts that carry current are enclosed and inaccessible while the current is on. The fuses are accessible only while the switch is in the off position. The laws of some states make the use of these enclosed switches mandatory.

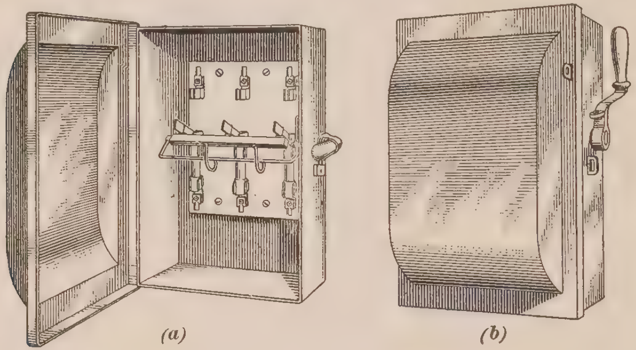


Fig. 35

SNAP SWITCHES

97. For lighting circuits carrying as high as 30 amperes at voltages up to and including 250 volts, the underwriters suggest the use of approved snap switches, so called because the make-and-break action is controlled by means of a spring in such a way that the switch opens or closes with a snap, no matter how slow the movement of the operator. Snap switches are of two general types, flush switches and surface switches; and of three general forms of construction: push-button switches, rotary switches, and toggle switches.

A push-button switch of the flush type is shown in Fig. 36 (*a*) and (*b*). When mounted, the faceplate shown in (*a*) comes flush against the wall.

A rotary switch of the surface type is shown in Fig. 37 (*a*) and (*b*). The printed disk inside the case rotates with the key and the words *ON* and *OFF* appear at the small opening in the case.

A toggle switch is operated by a small lever protruding through the faceplate, Fig. 38. The switch is so named because the snap action is secured by means of what is known as a toggle joint. Switch boxes for snap flush switches take the general form shown in Fig. 39.

98. When switches are placed side by side they are usually mounted in a single box called a *gang box*. When two flush switches are mounted one above the other, they are said to be *in tandem*. Gang switches usually have a common faceplate. This is also true of tandem switches. It is the usual practice to use rotary snap switches for exposed knob-and-cleat wiring and molding work. The switches are mounted on porcelain sub-bases that keep the wires at least one-half inch from the surface wired over. In exposed-conduit work, the push-button or the toggle switch is as frequently used as the rotary type.

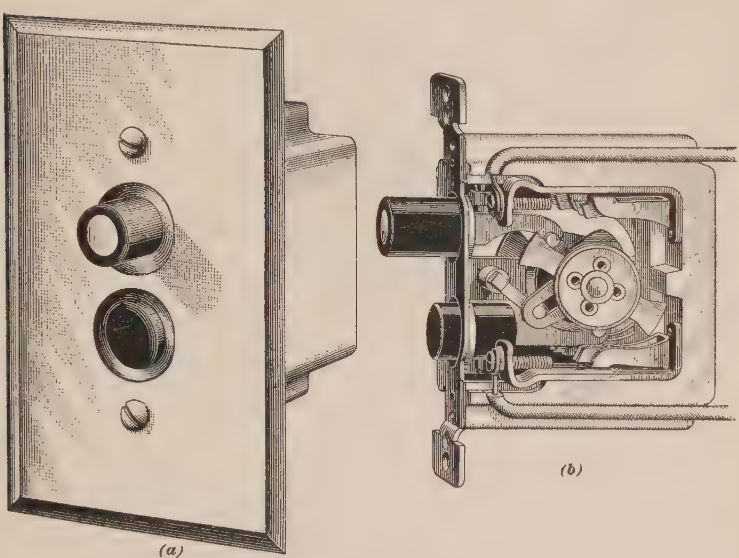
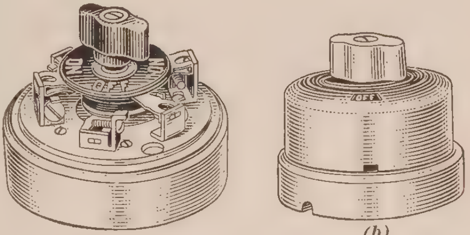

(a) (b)

FIG. 36



(a) (b)

FIG. 37

Either type is mounted in boxes similar to those used for concealed work.

Of the three types, either push-button or toggle switches are preferred wherever they can be used, because they are usually more rugged and durable than rotary switches.

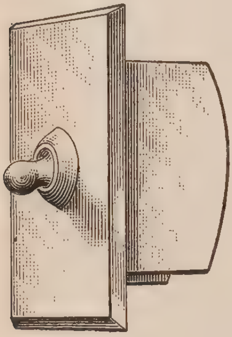


FIG. 38

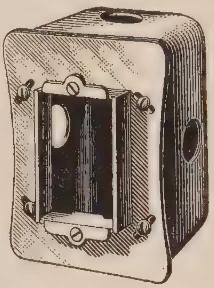


FIG. 39

99. Receptacles, or extension switches, types of which are shown in Fig. 40 (*a*) and (*b*) are used in connection with portable appliances such as reading lamps, small electric fans, and so forth. The portable appliance is wired through flexible cord to the insertion plug, or attachment plug, *a*, in (*a*), and connection to the building wiring is made by pushing or screwing the plug into the receptacle, depending on the type used. The faceplates of some types of receptacles are provided with a small door that covers the receptacle when the plug is not in place, as shown in (*b*),

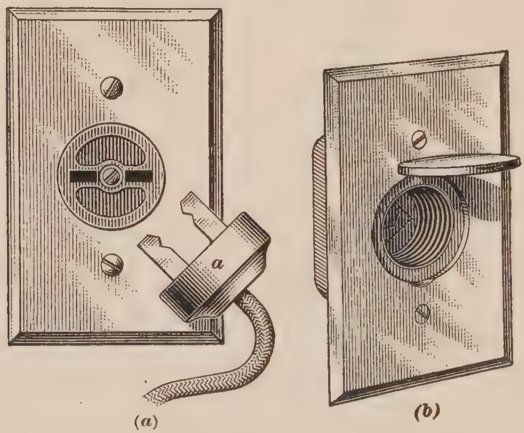


FIG. 40

thus preventing the accumulation of dust in the contact openings.

100. The location of receptacles depends, of course, on the probable location of appliances to be served by them. The use of electric-heating devices is increasing so rapidly that it is always well to plan for an ample number of outlets, especially in the more costly residences. They can be located in convenient positions in walls or floors. If located in a floor or close to a floor, an approved floor box should be used for enclosing them.

A **pendent switch,** an example of which is shown in Fig. 41, is suspended by a flexible cord and used for the control of fixtures out of reach or inconveniently located.

A **pull switch** is any switch operated by means of a pull chain or cord, as shown in Fig. 42.

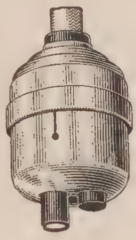


FIG. 41

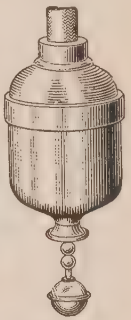


FIG. 42

A **canopy switch** is one mounted in a fixture canopy. A **fixture switch** is one installed as part of a fixture. Various other names, such as *wall switch* and *ceiling switch,* each practically self-defining, are used in designating switches.

101. To make switches luminous, a composition containing a small amount of radium compound may be used. Radiolite is one trade-name for such a composition. The radiolite is embedded in the form of a small button in the faceplate. A small cylinder or ball treated with the compound may be attached to a pull chain.

SPECIAL SWITCHES AND CONTROL CIRCUITS

102. A **three-way switch,** or **three-point switch,** is one that can be used to connect a conductor with either of two other conductors. Two such switches can be connected as shown in Fig. 43, so that one or more lamps can be controlled by either switch, regardless of the position of the other switch. For example, hall lamps can be controlled from either the upper or lower floor, or a garage lamp can be controlled from either the

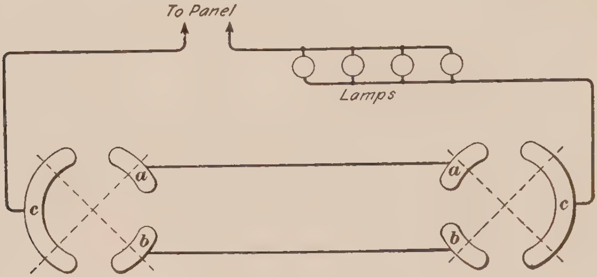


FIG. 43

house or the garage. In the illustration each switch may be closed in either of the two positions shown by dotted lines so that the circuit is complete either between contacts *a* and *c* or *b* and *c*. Thus, whatever may be the position of one of the switches, the other can be used to close or open the circuit through the lamps.

103. A **four-way, or four-point,** switch is one by which four wires can be connected in either of two combinations. In Fig. 44 are shown the connections of a combination of two three-point switches *A* and *C*, which may be on the first and third floors of a house, and a four-point switch *B*, which may be on

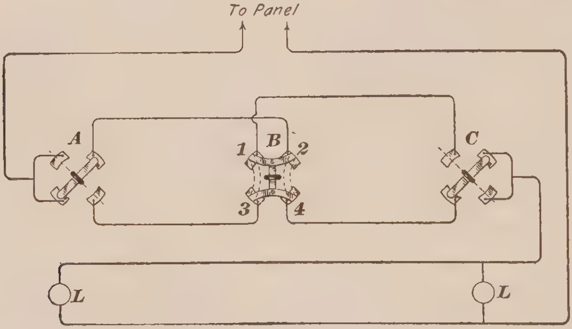


FIG 44

the second floor. Switch *B* is shown in the position to close the circuits between the points *1* and *2* and between the points *3* and *4*, but it can be operated to connect the point *1* with the point *3* and the point *2* with the point *4*. The hall lamps *L* so wired can be operated from any one of the three floors.

104. A method of connecting three-point switches and a master switch for the control of groups of lamps, is shown in Fig. 45. Each group of lamps can be switched on or off by turning the contact of a switch to the points *a* or *c*, but any or all groups switched off at the three-point switches can be controlled by the master switch *b*. This arrangement is sometimes employed in residences to enable all the lights to be thrown on by a master switch in an emergency such as burglary or a fire. The master switch may be placed in the owner's bedroom or any convenient place. It should be so installed that designing persons cannot tamper with it.

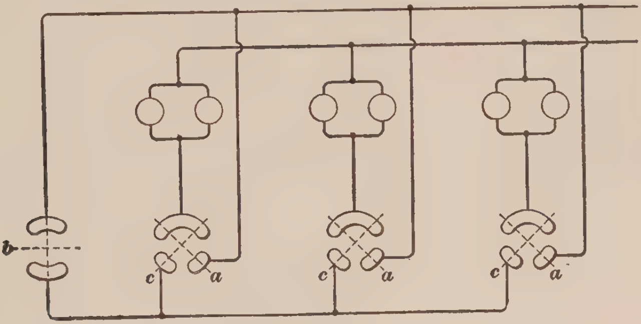
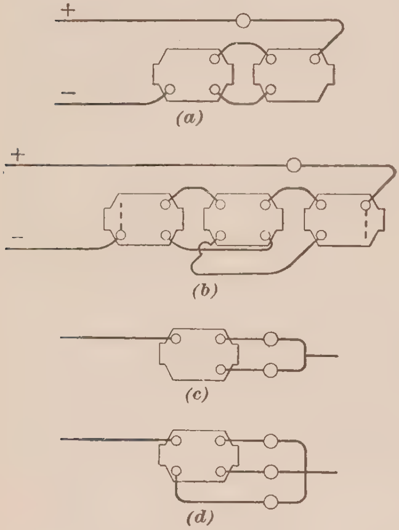


FIG. 45

105. Two three-way switches are shown in Figure 46 (*a*), designed to control a lamp, a group of lamps, appliances, or fixtures from either of two points. Two three-way switches and one four-way switch, view (*b*), are designed to control a lamp or group of lamps, or fixtures, from any one of three points. Two-circuit or three-circuit switches are frequently used to control the lamps of an electrolier and are called *electrolier switches*. Views (*c*) and (*d*) show symbolic representations of the two types of these switches.

106. Switches for series-parallel combinations are useful for obtaining various degrees of heat in electric heating appliances. They are frequently called *two-heat switches* or *three-heat switches,* as the case may be. A three-heat switch is one arranged to give a high-medium-low-off combination, or the reverse. A *remote-control* switch is a semiautomatic switch that can be opened or closed by means of an operating switch, or pilot switch. The remote-control switch is usually located near the apparatus to be operated and the pilot switch at a remote point more convenient of access. The remote-control system is of broad application. It is often used for the control of large motors in industrial buildings; also in public buildings and residences this system may be used to control a stationary vacuum-cleaner equipment. Where used for a cleaning system, the equipment is generally located in the basement of the building, and the pilot switches are located in various parts of the building where the cleaning devices are used. Lighting systems may also be controlled by pilot switches. A patrolman may shut off the lamps of a large store without entering the building. Lamps of an auditorium may be controlled from the stage or any part of the building, if so desired.



(a)

(b)

(c)

(d)

FIG. 46

107. There are many other kinds of automatic and semiautomatic switches, each kind adapted to a special purpose. One of these is the time switch which consists essentially of clockwork mechanically interconnected with a switch mechanism in such a manner as to open or close the circuit at a given time. Time switches are frequently used to control lamps of show windows and of electric signs.

108. Cellar lamps are frequently wired to be controlled by a switch located in a first-story room. A red pilot lamp, or indicator lamp, should be installed adjoining the switch that controls these cellar lamps to serve as a reminder that the cellar lamp has been left burning. Pilot lamps as shown in Fig. 47 are frequently used for this purpose. In (*a*) is shown the complete lamp, and in (*b*) the lamp with the faceplate removed.

109. An automatic door switch, as shown in Fig. 48, is used for automatically operating a lamp, or group of lamps, upon the opening or the closing of a door. The switch is mortised into the door jamb and is operated by the action of a plunger that is pressed or released by the strike of the swinging door. Door switches find wide application in residences, where they are used in linen closets, clothes closets, pantries, cupboards, and toilets.

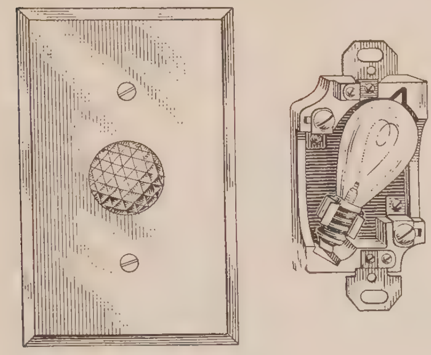

(a) *(b)*

FIG. 47

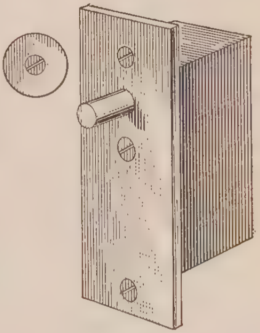


FIG. 48

EXPOSED WIRING

WIRE-CARRYING DEVICES

110. **Knob insulators** for the support of wires are made in a variety of forms of which the solid knob, Fig. 49, is the most commonly used in interiors for carrying wires larger than No. 10. For smaller wires, split-knob insulators, examples of which are shown in Figs. 50 and 51, are used.

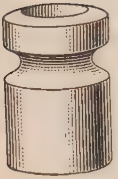


FIG. 49

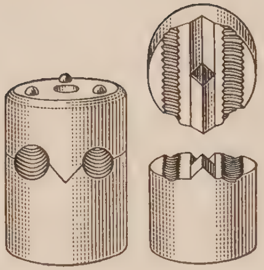


FIG. 50

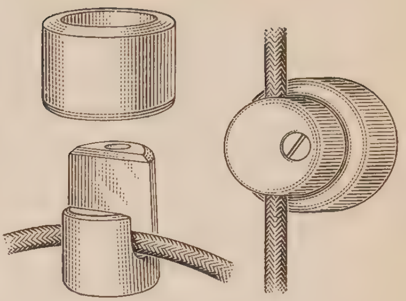


FIG. 51

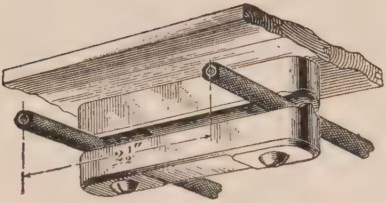


FIG. 52

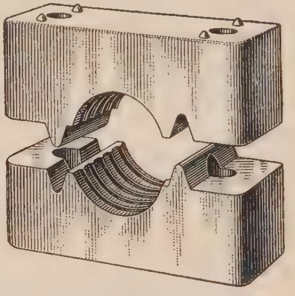


FIG. 53

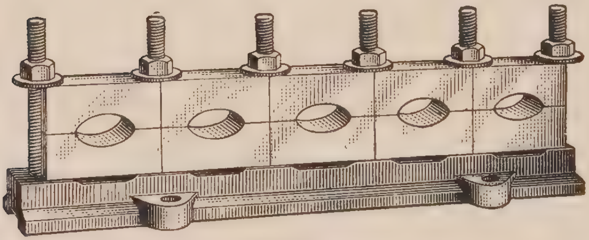


FIG. 54

Cleats are also made in a variety of styles, each adapted to a particular kind of service. A one-wire cleat accommodates only one wire; a two-wire cleat, Fig. 52, is grooved for two wires; a *three-wire cleat,* for three wires. The two- and three-wire cleats are made for wires as large as No. 2; for larger conductors a cleat for each wire is preferred. A typical cleat for large conductors is shown in Fig. 53. Where a number of conductors follow the same run, the usual practice is to clamp the cleats in iron frames, as in Fig. 54.

Split bushings clamped in iron frames, as in Fig. 55, are also useful for carrying wires on walls and ceilings in exposed work.

Insulators for interior work are usually made of glazed porcelain, though glass is sometimes used.

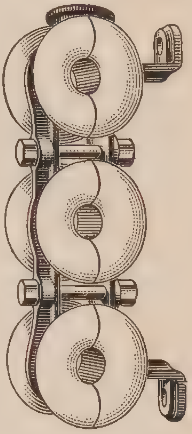


Fig. 55

EXPOSED WIRING INSTALLATION

111. Methods Used.—Methods of carrying exposed wires on wooden ceilings are shown in Fig. 56. Wires for mains not smaller than No. 8, if not likely to be disturbed, may be separated from each other about 6 inches and fastened on knobs attached to the timbers, as indicated at *a*. Smaller wires, or wires likely to be disturbed, as by the piling of boxes or the moving of material, should be carried around the beams on knobs or cleats, as shown at *b*. Small wires crossing beams can

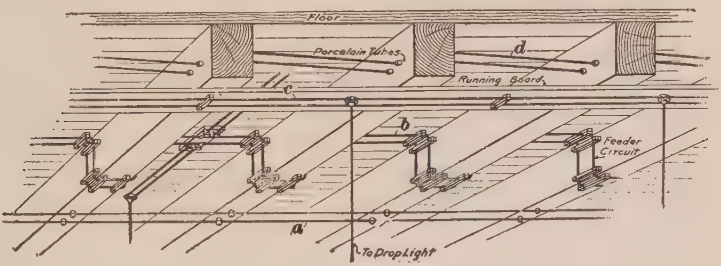


Fig. 56

also be placed on running boards, as shown at *c*, or carried through the beams in unglazed porcelain tubes, as at *d*. When the wires are run as in circuit *a*, guard strips are sometimes placed on each side to protect them from injury. Where drop lights—lamps suspended by cords—are to be hung, ceiling rosettes, as shown in Fig. 57, are used. In damp places the wires can be protected from dripping water by fastening the insulators in so-called wiring troughs.

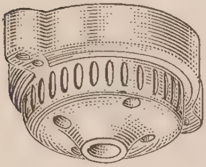


FIG. 57

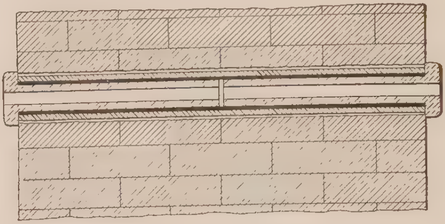


FIG. 58

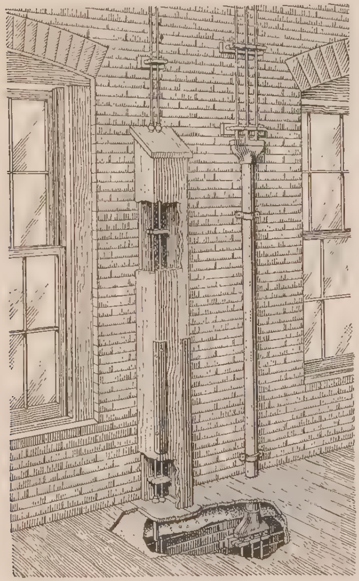


FIG. 59

112. A recommended method of running wires through thick walls is shown in Fig. 58, namely, in porcelain tubes that fit closely in an iron pipe. In thin walls or partitions, a single porcelain bushing can be used without the iron pipe. Where vertical runs of exposed wiring are carried through floors, the wires should be protected to a height of 7 feet from the floor by a method similar to either of those illustrated in Fig. 59.

113. For supporting racks carrying a number of heavy conductors, it is preferable to drill and tap the iron beams or columns and fasten the racks to them by means of machine bolts.

114. In any job of exposed wiring the most direct runs for the circuit should be selected. If possible, the crossing of pipes, especially steam pipes, should be avoided. Where wires themselves cross, the upper ones should be protected by porcelain tubes.

INSULATION REQUIREMENTS

115. Varieties of Insulation.—The insulating covering on conductors for open wiring on insulators need not be of the high grade required in other systems of wiring, because either the glass or porcelain insulators protect the conductors from each other and from the building, pipes, or other conducting material; the covering on the conductor is simply an additional safeguard. Rubber-insulated conductors are, therefore, unnecessary for this kind of wiring in dry places, and the general practice is to use conductors having slow-burning weather-proof insulation where there is apt to be any dampness; and slow-burning insulation in dry places, particularly where the temperatures are higher than normal. Both of these insulations are cheaper and more durable than rubber. Rubber insulation is required, however, for very damp places.

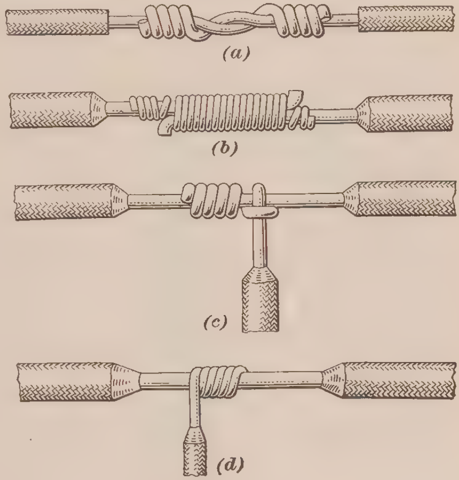


FIG. 60

116. Joints.—It is best wherever possible to avoid making joints in wires. When they must be made, however, the code requires that the joints be made mechanically and electrically secure. In making the joints the insulating material is first stripped from the portions to be joined and the wire scraped until it is clean and bright and these portions twisted together. Fig. 60 (*a*) and (*b*) show splicing joints in continuous circuits and (*c*) and (*d*) show joints where one wire is connected to another to form a branch circuit. After the wires are twisted together and soldered, they are covered with insulating tape.

Joints in wires are not permitted in conduit systems of wiring except in outlet or junction boxes.

APPLICATIONS AND ADVANTAGES OF EXPOSED WIRING

117. Exposed wiring on insulators is especially adapted to mills, factories, and other buildings where appearance is not an object. This method of wiring is objectionable, however, in locations where the conductors may be damaged or deranged, or where there is no unobstructed space in which the conductors can be run without crossing pipes or other conductors.

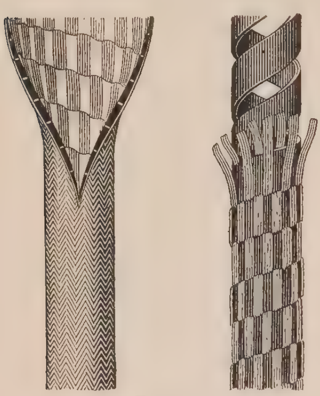


Fig. 61

CONCEALED KNOB-AND-TUBE WORK

118. Installation Methods. In concealed knob-and-tube work, the wires are carried on porcelain knobs in the spaces between beams and studs, and in porcelain tubes where they pass through timbers. Another accessory of this method of wiring is flexible tubing, or fiber tubing, a sample of one variety of which is illustrated in Fig. 61. The electrician generally speaks of fiber tubing as circular loom, or simply loom, to use a familiar trade-name.

119. Illustrations taken from typical installations of knob-and-tube work are given in Figs. 62, 63, and 64, showing the method of running the wires, the flexible tubing *a*, Fig. 62, and for supporting the outlet boxes *a*, Figs 63 and 64, and *b*, Fig. 62.

120. Convenient and quick methods of fastening switches and outlet boxes are shown in Fig. 65 (*a*) and (*b*). In (*a*) the outlet boxes *a* are secured to iron braces *b* that are fastened to the vertical studs *c* of the partition. At *a* in (*b*) are shown lath that are nailed to the studs *b* and to which plaster is applied.

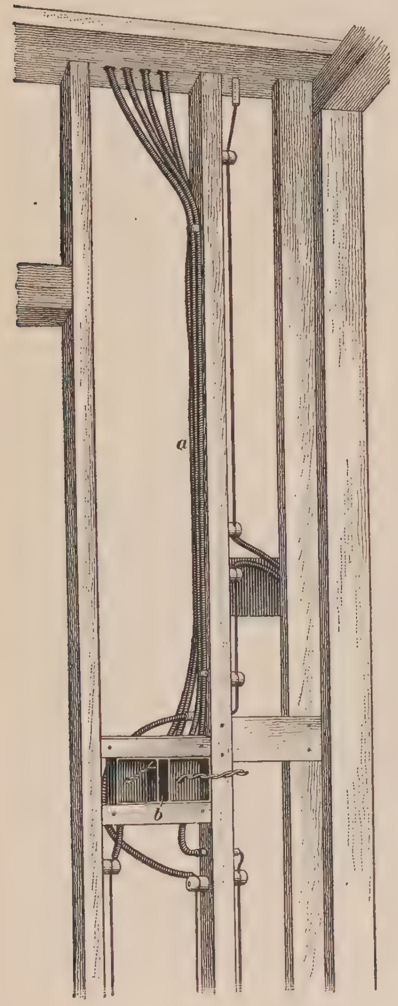


FIG. 62

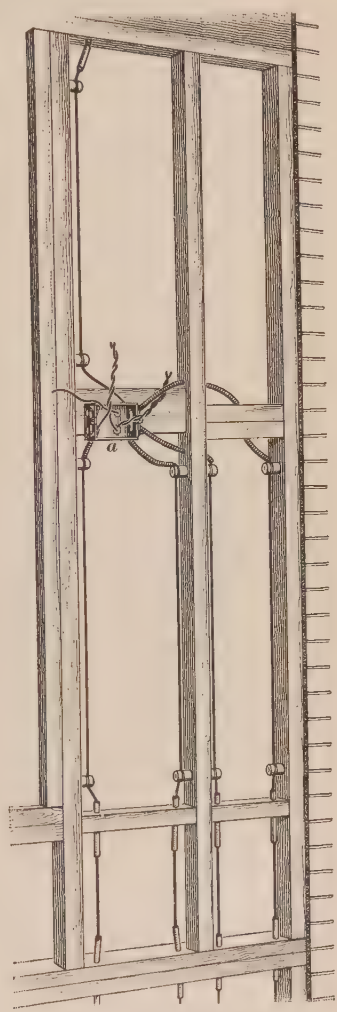


FIG. 63

The box shown at *c* is supported by braces *d* to which are fastened vertical bands *e* to hold the ends of the lath in place.

121. General Requirements.—According to the code, wires for knob-and-tube work must be covered with approved rubber insulation. The wires must be kept 5 inches apart, if possible; otherwise, metal conduit or armored cable must be used, except for voltages of 300 or less, when flexible tubing may be used, as at *a*, Fig. 62. It is advisable, where possible, to fasten the wires to separate beams or studs, as in Figs. 63 and 64, in order to keep them as far apart as practicable. The conductors must be supported at least every 4½ feet, and if they are liable to be disturbed the supports must be placed closer together. Each wire that passes through a sill or header should have an additional porcelain tube above the one through the timber, to protect the wires from becoming embedded in plaster.

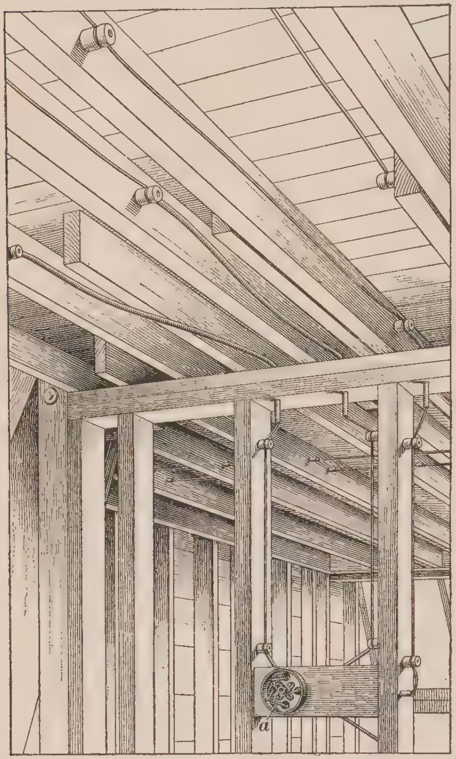
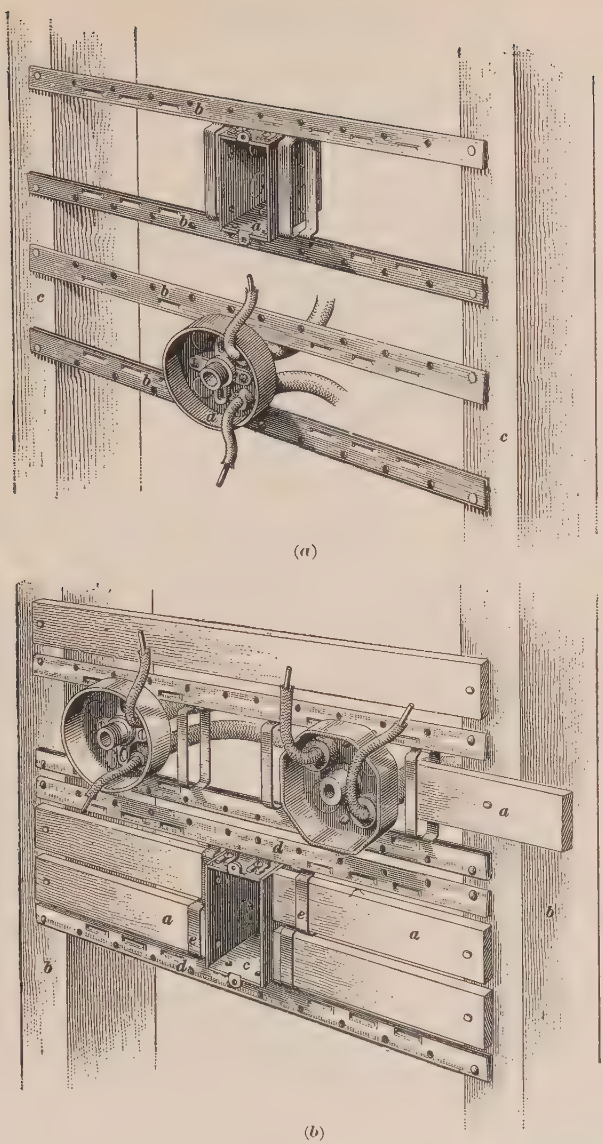


FIG. 64



(a)

(b)

Fig. 65

MOLDING WORK

WOODEN MOLDING

122. Description.—Wooden molding, Fig. 66, consists of a base *a*, with two or more grooves for holding the wires, and capping *b* to give it a finished appearance. The base is first fastened to the surface to be wired; the wires are then put in place and held temporarily by small tacks or brads; finally the capping is nailed or screwed in place. Special porcelain fittings, called *taplets*, shown in Fig. 67, are used at places where the moldings intersect, to splice wires for junction leads. These fittings insulate and protect the joints in the wiring.

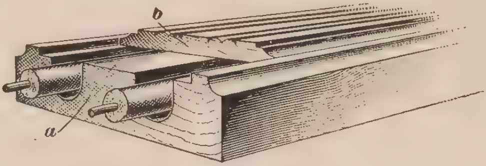


Fig. 66

123. Requirements for Wooden-Molding Work.—In factories and stores, warehouses, and so forth, wooden molding on vertical runs must not approach a floor closer than 6 feet. Below this point and through the floor the circuits must be carried in pipe conduit with suitable outlets for connecting it to the molding. In places where the molding is less liable to mechanical injury, as in residences and office buildings, the molding can be brought down to the floor and protected at the bottom by means of an iron box called a *kick box*. The code rules do not per-

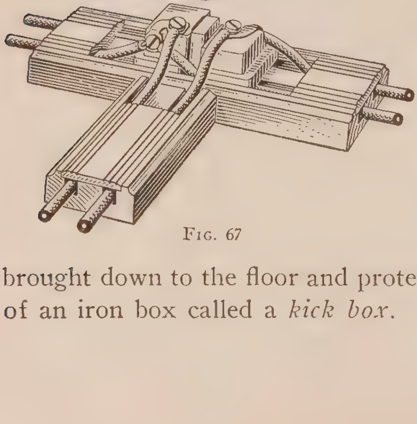


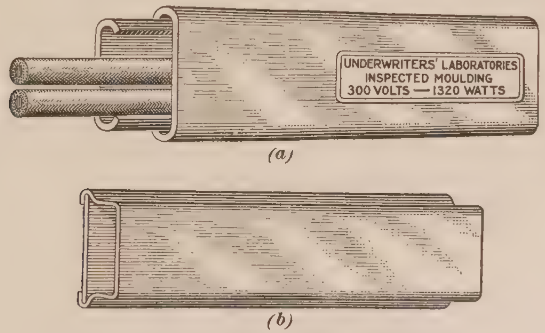
Fig. 67

mit wooden molding to be run through walls and floors; in such places porcelain tubes or metal conduits must be used to carry the wires.

124. Advantages and Disadvantages of Wooden Molding. Wiring in wooden molding, properly installed, presents a better appearance than any other form of exposed wiring. Moreover, molding can be run as cornices in halls and rooms, so that its appearance is scarcely noticeable. By fishing part of the wires through conduits and running the rest in molding, the expense of wiring completed buildings can be made less than if all the wires were in conduits, while the appearance is equally good. Wooden moldings are not, however, fireproof nor moisture proof. They are never used in damp places and are never concealed.

METAL MOLDING

125. Metal molding, Fig. 68 (*a*) and (*b*), has a trough-shaped base to carry the wires, and a capping to conceal and protect them. The base is drilled and countersunk at frequent intervals in order that it can be secured to the surface to be wired. The heads of the screws that hold the base must be flush with the inner surface of the base. Special fittings are also made for this molding for intersecting points where splice wires occur for branch leads. Two of these are shown in Fig. 69 (*a*) and (*b*).



(*a*)

(*b*)

Fig. 68

The obvious advantage of metal molding is that it is fireproof. Another advantage, as compared with wooden molding, is that it can be run through walls and partitions, provided a continuous piece is used for the purpose, and provided there is no danger from mechanical injury or dampness. The metal molding also occupies less space than the wooden molding.

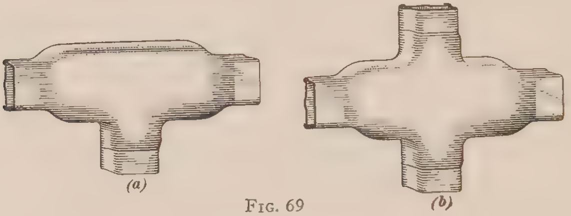


Fig. 69

ELECTRIC WIRING
(PART 2)

LIGHT AND POWER WIRING

CONDUIT WORK

RIGID CONDUIT

1. Iron-Pipe Conduits.—Although the most expensive, the best method of installing concealed electric wiring is by means of rigid iron-pipe conduits, as shown in Fig. 1. The conduit forms a raceway or channel between various outlets through which the wires are pulled or *fished* by means of a long, thin piece of steel called a *snake*.

2. Rigid iron pipe is the only type of conduit that should be considered for fireproof buildings, as this can be installed during the period of building construction, and the conductors pulled in after the plaster work is done. If any trouble occurs in any of the concealed circuits at any time after the building is completed, the wires can be withdrawn and the new ones inserted.

3. Iron-pipe conduit is practically gas pipe protected inside and outside by a zinc or black-enamel coating. The coating is applied to protect the pipe from deteriorating and to preserve the raceway. The coating also forms on the inside of the pipe a smooth surface that facilitates the pulling in of the wires. Some engineers prefer a conduit with enamel inside and zinc outside, in case the conduits are to be embedded in concrete.

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4. Conduits installed in places where the coating is likely to be acted upon by acids should preferably be enameled, as the action on coverings containing zinc destroys the coating. In order that the wires may be drawn through the conduit easily and without injury to the insulation, the inside edges of the ends of the pipe are reamed smooth before the protective coating is applied.

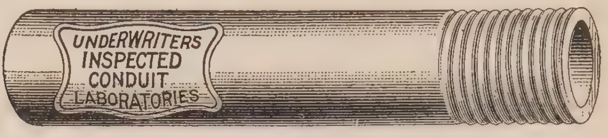


FIG. 1

5. Rigid conduits are made in what is known to the trade as gas-pipe sizes from ½ inch to 6 inches in diameter. The trade sizes up to 3 inches and the actual inside and outside diameters of these pipes are shown in Table I The conduit is shipped from the factory in 10-foot lengths threaded on each end and provided with at least one coupling for each length. Any enamel on the threads should be removed by the electrician before the conduit is installed. When a piece of conduit is cut and threaded on the job, each cut should be reamed to remove the burr caused by the cutting. This is very important, as most of the trouble which develops in conduit is due to poor workmanship.

TABLE I

CROSS-SECTIONAL DIMENSIONS OF RIGID CONDUIT

Standard Pipe Size Inches	Inside Diameter Inches	Outside Diameter Inches
½	.622	.840
¾	.824	1.050
1	1.049	1.315
1¼	1.380	1.660
1½	1.610	1.900
2	2.067	2.375
2½	2.469	2.875
3	3.068	3.500

MISCELLANEOUS CONDUIT FITTINGS

6. Condulets.—Manufacturers produce approved fittings to meet nearly every conceivable requirement of conduit work, and market them under various trade names. Four of these fittings known as *condulets,* are shown in Fig. 2 (*a*) to (*d*), and the places in the conduit system where they are used are shown at *a* to *d*, Fig. 3.

7. Unilets, Taplets, and Multilets.—Similar fittings are made by other manufacturers to meet the same requirements, and are known as *unilets, taplets,* and *multilets.* These fittings are made in all standard pipe sizes up to 4 inches, and in shapes suited to all wiring purposes. Most of the special fittings are designed to meet the requirements of exposed work, in which neatness is generally an important factor; but many of them are adapted to concealed work also. In exposed work, such fittings require no means of support other than that of the conduit to which they are screwed, but for concealed work the underwriters require additional means of support.

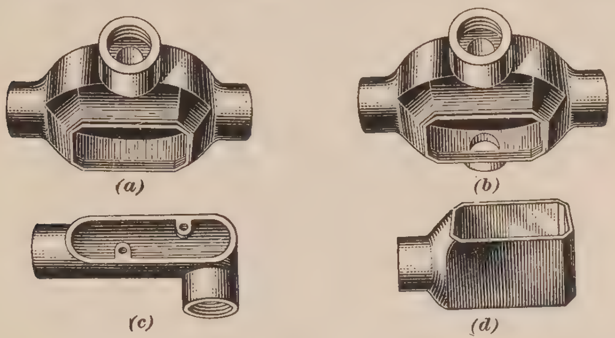


FIG. 2

8. The ordinary gas-pipe **L**'s and **T**'s should never be used for conduit work, not only because such fittings are generally rough on the inside, but because they do not allow radii large enough to permit the wires to be inserted or withdrawn easily.

9. Outlet, or Knockout, Boxes.—An outlet box consists of a zinc-coated or black-enameled sheet-steel box with openings through which conduits enter, and into which the wires are brought for connection to a fixture, switch, or other electrical device. The most usual forms of outlet boxes are shown in Fig. 4, the box in (*a*) being round, and the box in (*b*) square. The boxes are made of stamped steel, and are so constructed that openings to receive the conduits can be readily made at the back or at the sides by knocking out some of the circular pieces of metal with a hammer, hence the name *knock-*

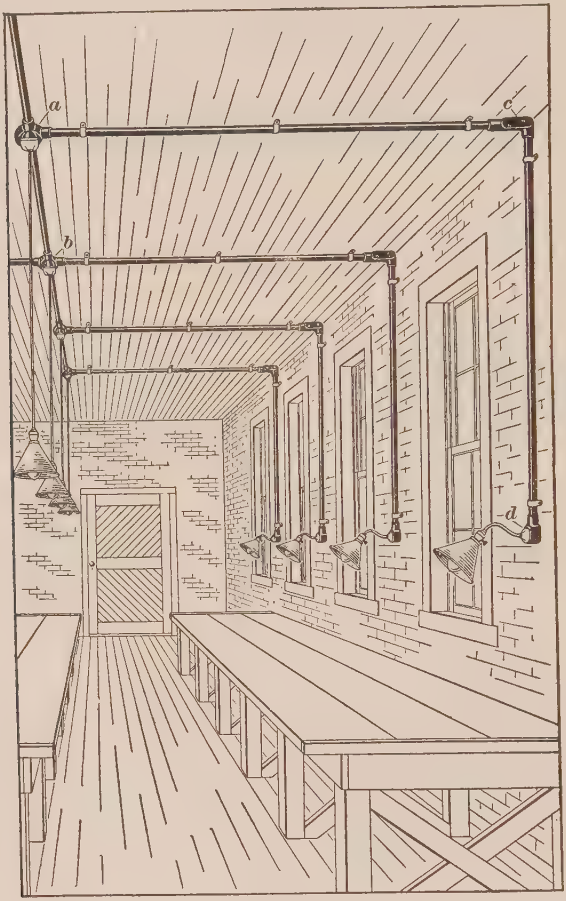


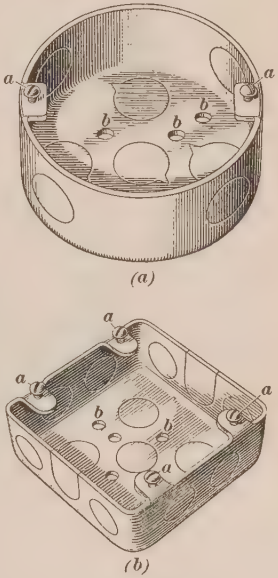
FIG. 3

out boxes. The lugs and setscrews *a* are for the attachment of suitable covers, the forms of which depend on the use to which the box is to be put. Holes *b* in the bottom provide means of securing the box to its support. Outlet boxes are installed at the same time as the conduit.

10. Two methods of fastening the ends of rigid conduit to an outlet box are shown in Fig. 5 (*a*). By the first method a coupling *a* is screwed to the threaded end of the conduit *b*, and a nipple *c* is thrust through the hole in the box from the inside and screwed into the coupling. The wall *d* of the box is held between the end of the coupling and the flange *e* of the nipple. This coupling is shown in (*c*).

11. By the second method shown in Fig. 5 (*a*) a locknut *f* is screwed on the end of the conduit *g*, which is then thrust through the hole in the wall of the box *d*, and a bushing *h* is screwed on so as to hold the box securely between the bushing and the locknut. The bushing is shown in (*d*) and the locknut in (*c*).

12. Floor Boxes.—Floor boxes are special forms of outlet boxes designed for installation in a floor. They should be water-tight to prevent the entrance of mop water. Because of the difficulty of installing the regular floor box at the exact level required by the finished floor, the type of box shown in Fig. 6 is often used. The lower part of this box is installed with the conduit, and does not need to be perfectly level. The upper part of the box is installed later, and can be adjusted as shown to fit the lower part, and also to aline with the floor level. The joints between these two parts should be filled completely with cement. The lower part of this box is



(*a*)

(*b*)

Fig. 4

made of thicker metal than are knockout boxes, and holes, to which plugs are fitted, are bored in the four sides. When it is desired to have a conduit enter these holes, the plugs are removed and the conduit attached to the box in the manner described for the ordinary knockout box.

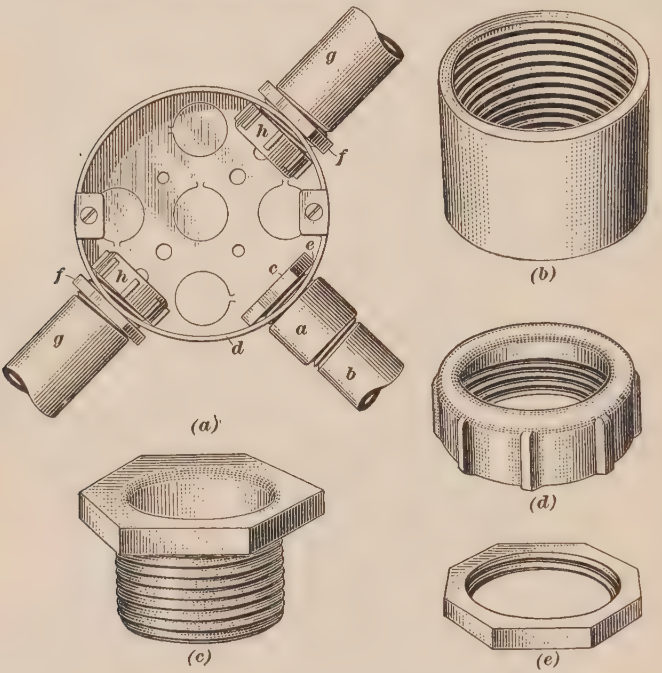


FIG. 5

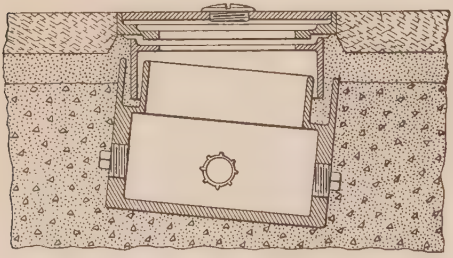


FIG. 6

13. Junction Boxes. A junction box, as the name implies, is used where two or more conduit lines intersect. The regular outlet box shown in Fig. 4 is generally used as a junction box when only a few conduit connections are required, while a large box, as shown at *a* in Fig. 7, is used when there are many connections to be made. Large boxes are frequently made especially to meet the exact requirements of the electrical installation. They must be provided with the same character of holes as the small box to receive the conduits, and the face or one side of the boxes must be provided with a door *b* or movable cover to allow of access to interior of the box for the installation or repair of the wires in the conduits.

Junction boxes are sometimes called *pull boxes* because the wires are pulled through the conduits from these places. On this account the boxes should be so located that they will be easily accessible. Junction boxes, instead of right-angle bends, are often installed in the conduits. They are so used when the conduit run has a number of these bends and the pulling of the wires would be difficult on account of the excessive friction at these places.

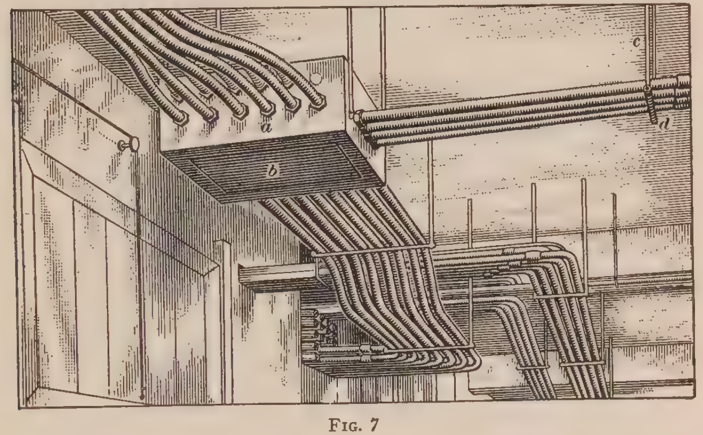


FIG. 7

14. Installing Horizontal Runs of Concealed Conduit. The manner of installing horizontal runs of concealed conduit in fireproof buildings depends on the type of the floor construction. If hollow tile is used for the floor, the conduits are not installed until the tile work has been completed and the wood centering removed. The conduits are then laid on the top of the tile and the ends of conduit bent to turn down and connect with the outlet box on the ceiling below, as shown in Fig. 8. In buildings having a hung ceiling the conduits are run on top of the channel iron which supports the ceiling.

15. If the floor construction is of reinforced concrete, the conduits should be placed on the wood centering erected to receive the concrete. It will then become embedded in the concrete of the floor construction. It is very important, however, that provision be made in the architect's specifications for installing these conduits at the proper time, so that the general work of the building will not be delayed. If the steel reinforcement of the concrete consists of bars, the conduit may be installed before the steel reinforcement, the pipe and fittings being laid directly on the wood forms. In most cases the conduit is placed above the bars, as in Fig. 9, and the boxes are placed below the bars. Junction boxes are shown at *a* and a light outlet box at *b*. When the reinforcement is to be of an expanded-metal type, the conduit is usually placed above the reinforcement, as shown in Fig. 10, and openings are cut in the reinforcement to receive the outlet boxes *a* and *b*. The conduit should be wired securely to the reinforcement, and the boxes should be nailed lightly to the wood forms.

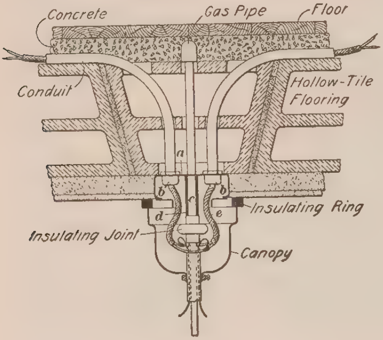


FIG. 8

16. In wooden frame buildings, conduits that run across the joists may be carried in grooves, so that the conduit is out of the way of the flooring, if laid on top of the joists, or in the plastering if laid on the under side of the joists. If conduits run parallel with the joists they are usually held in place by means of pipe straps nailed to the joists as shown in Fig. 11.

17. Installing Vertical Runs of Concealed Conduits. Single vertical runs, or *risers*, of concealed pipe conduits are

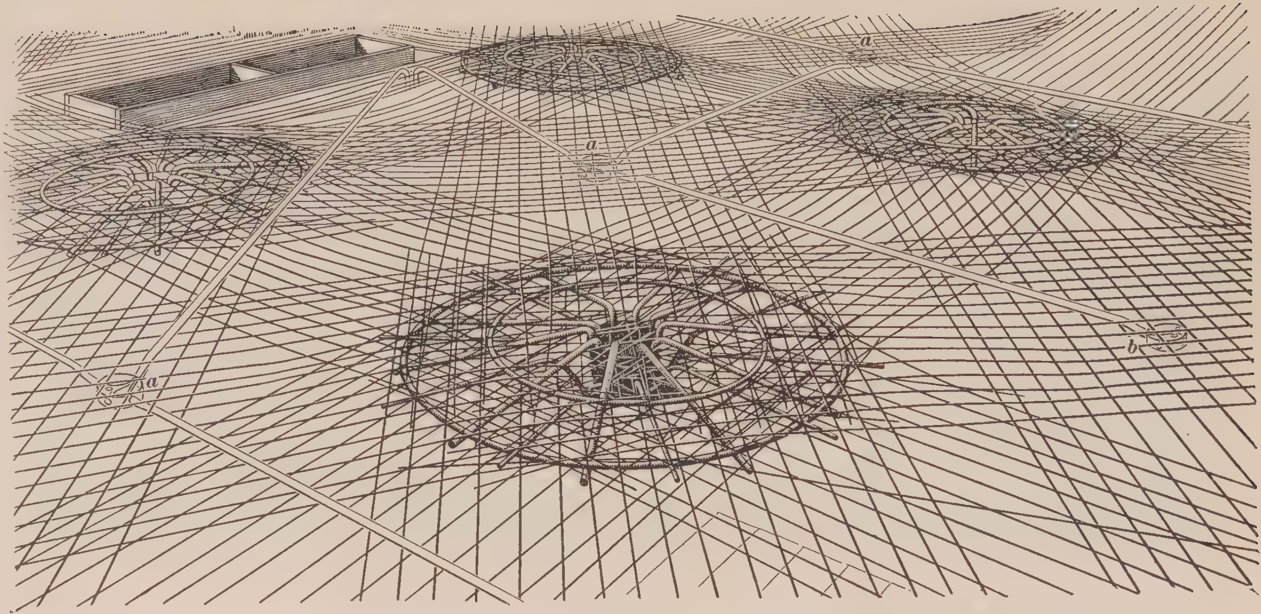


FIG. 9

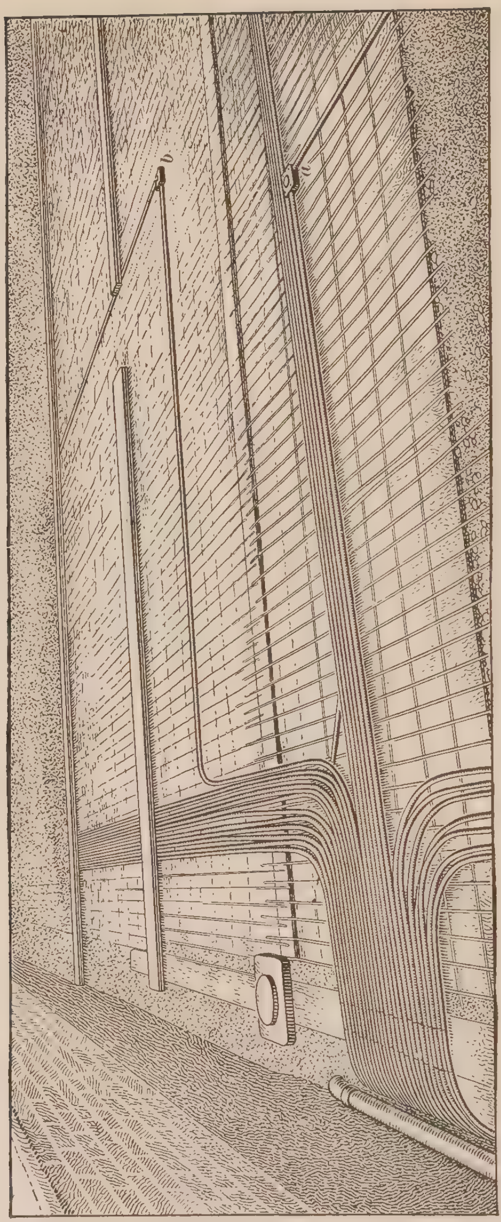


Fig. 10

generally installed sufficiently in advance of the masonry work that they can be built into the wall. When so installed, the boxes are usually attached to the conduits and both conduits and boxes are braced in such a manner that they will be held in a proper position during the erection of the wall. When the exact location desired for the box cannot be determined at this time, it is customary to terminate the conduits below the approximate location contemplated and a chase is left in the wall for the extension of conduits at a later time. This is very often required where the outlets are to be located in the center of a stile or panel of a wainscot.

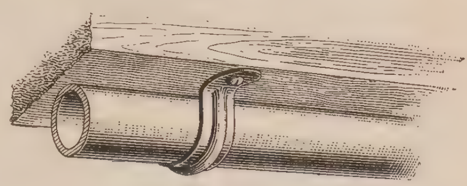


Fig. 11

18. Conduits that are run after the wall has been erected require the wall to be grooved or channeled to receive the pipe. The channel will require to be covered with metal lath to receive the plaster. Chases in the wall are usually provided for large conduits or for a number of small ones when they adjoin each other. A special wire shaft or pipe shaft is the best method for vertical runs of large conduits, although an elevator shaft may be used for this purpose if the location is suitable for the

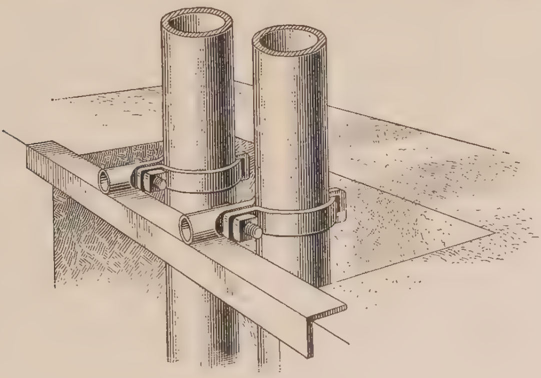


Fig. 12

work. Long vertical runs of conduits should have extra supports placed at each alternate story height to relieve the stress on the pipe couplings. These supports are usually obtained by the use of pipe clamps as shown in Fig. 12. The clamps are secured to the pipes and rest on steel angles previously built into the wall.

19. Installation Procedure.—The installation of the electric wiring system in a fireproof building is usually complex, and is of such a character that when once installed, it is hard to change. The architect should confer with an electrical engineer and determine upon all electrical matters before the structure is started, so that the plans of the structure may provide for all requirements of the equipment and its installation. The architect should know the size and location of all wire shafts, or pipe shafts, as they are frequently called, that will be required, also the size and location of all panel boards and chases in walls that are to be left for main conduits. If the size of these main conduits and the panel boards can be determined sufficiently early to permit the electrical contractor to have these parts of the equipment on the premises before the masonry walls are started, they may be set in desired positions and the walls built around them. This will insure better construction of the walls than to leave chases and recesses and fill in the unused spaces after the electric materials have been installed. If these conduits are built into the wall as suggested, they should terminate at the floor and ceiling with bends to which the horizontal lines can be connected when the conduits are to be continued to the various outlets.

20. General Requirements for Concealed-Conduit Work. The size of conduit to be used depends on the size and number of conductors to be drawn in, the length of the run and the number of bends in the run. The National Electrical Code contains a table covering conduit sizes for average conditions. The conduits must be continuous between outlets, junction boxes, etc., and must be secured thereto in such a manner as to make a good mechanical and electrical connection. At all points where conduits enter pull boxes, junction boxes, cut-out cabinets, and similar accessories, approved fittings, called *bushings, plates,* or *nipples,* must be provided to protect the wires from injury as they are drawn. The conduit system must be effectively grounded.

21. The conduits must be installed first as a complete system before the conductors are drawn in. Conduit ends should never be left open for any length of time, as they are liable to become stopped with refuse, or water may enter them. The ends should always be kept closed by wooden plugs, corks, or gas caps until the wires are to be installed. Gas caps are preferred, as they can be screwed on to the ends of the pipe, and are not as likely to be removed as the wood plugs or the corks. All the wires for conduit work should be rubber-insulated and protected by a double braid, though the underwriters permit the single braid for single conductors in sizes smaller than No. 6 B. & S. gauge. When the entrance of moisture into a conduit is expected, lead-covered wire should be used.

22. All wires of the same part (feeder, main, or branch) of an alternating-current circuit must be installed in the same conduit. Conductors in vertical conduits must be supported within the conduit system at distances depending on the size of the conductors. Sometimes this necessitates the installation of steel boxes, similar to junction boxes, or distribution cabinets, but containing approved insulating clamps for the conductors.

EXPOSED PIPE-CONDUIT WORK

23. Supporting Conduit.—The clamp shown in Fig. 11 can be easily fastened to wood, but when laid against a terra-cotta wall toggle bolts are needed, as shown in Fig. 13. To support conduit against a brick wall, expansion bolts are used, as shown in Fig. 14. Where the conduit is carried on steel beams, special clamps, as shown in Fig. 15 (*a*) and (*b*), are employed. To provide for the support of exposed conduit (or any other kind of wiring) from concrete beams, cast-iron inserts, as shown in Fig. 16, which are recessed for machine bolts or studs, are placed in the forms before the concrete is poured. A view of the insert is shown in (*a*), and a section in (*b*). The face of each insert is left exposed and the conduit clamp or fastening can be bolted to it.

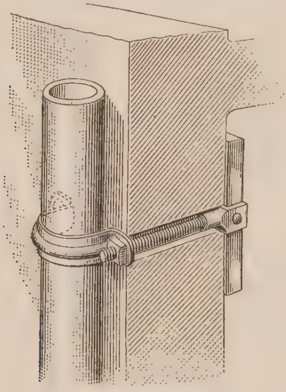


Fig. 13

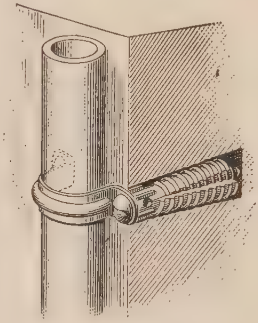
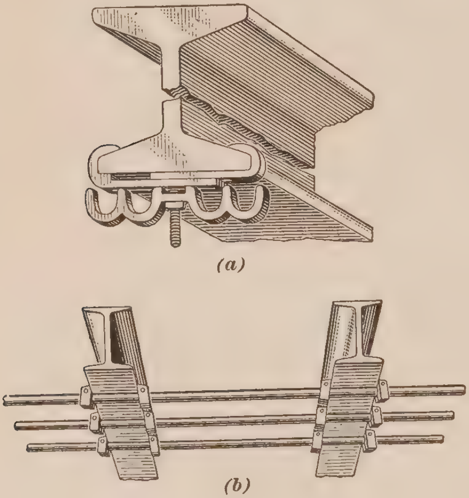


Fig. 14

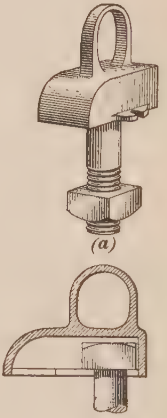
To avoid drilling of masonry, pipe nipples of the required size can be placed in the proper locations in walls, floors, or partitions during their construction and the conduit later be coupled to the nipples. This use of nipples is especially desir-



(*a*)

(*b*)

Fig. 15



(*a*)

(*b*)

Fig. 16

able in concrete work in which the nipples can be held in the forms while the concrete is being poured. Until the coupling is being done, however, the nipples should be kept plugged. A method of supporting fairly heavy runs of conduit is shown in Fig. 7. Rods *c* support pipes *d*, on which the conduits rest.

24. The general requirements for concealed-conduit work apply to exposed work also. In work of this nature, where special fittings are not used, care should be taken to use right-angle bends of at least 6-inch radius, and otherwise to run the conduit so as to present a neat appearance. The conduits should be securely fastened at distances not exceeding 8 feet by clamps or supports, as previously described. Very frequently, circuit work in exposed conduits is preferable to concealed work, because of the probability of changing or shifting circuits at some future time. Exposed conduits may also be advisable in finished buildings where structural conditions or lack of space makes concealment difficult without materially disturbing the building, but metal molding is generally used for exposed work.

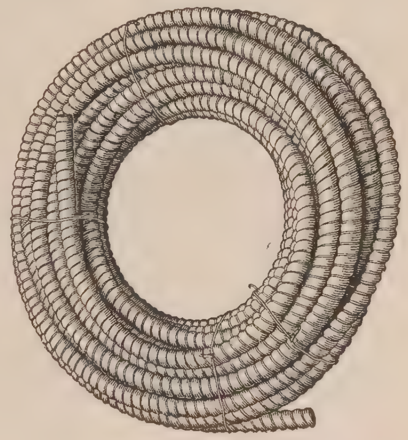


FIG. 17

FLEXIBLE-CONDUIT WORK

25. Flexible conduit work shown in Fig. 17 is made by winding two trough-shaped metal strips spirally on each other in such a manner that both the inside and the outside of the tube have a convex surface of a strip exposed. This conduit is fairly tight, though not altogether waterproof and is absolutely nail-proof. It is extremely strong and can be bent in any direction. The wireman usually calls it Greenfield conduit, giving a general application to the trade name of a prominent manufacturer.

26. An example of flexible-conduit installation is illustrated in Fig. 18. Here a combination gas-and-electric lighting system is to be used. Flexible conduits also are always completely placed before the wires are drawn in, and usually the wires are not inserted until after the building is plastered. This conduit also makes an excellent material to use when wiring buildings that are already completed, as small openings can be made in the floor, wall, or ceiling and the conduit fished from point to point. The material, weight, and form of flexible metal conduits are required to give as substantial protection as rigid conduits. It is essential, however, to fasten flexible conduit securely at frequent intervals in order to permit easy insertion of the wires.

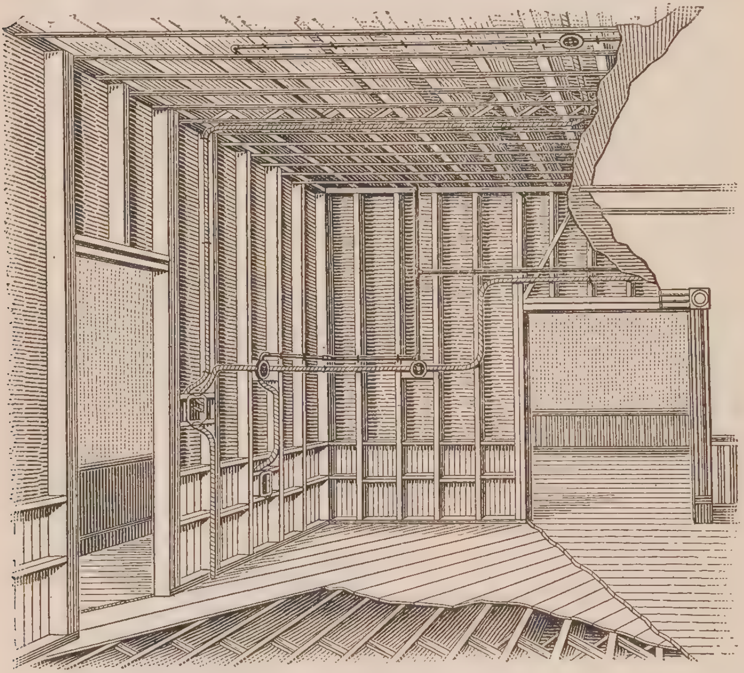


FIG. 18

The Code rules for pipe conduit apply to flexible conduit also. Wherever the conduit passes through slots in beams or studding, iron plates should be used to protect it from nails.

ARMORED CABLE

27. Armored cable, as shown in Fig. 19, is not, strictly speaking, a form of conduit, but it so nearly resembles flexible conduit in construction and installation that it is most conveniently described under conduit work. The electrician usually calls it BX cable, using the trade name of one of the earliest makes.

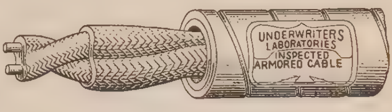


FIG. 19

28. Cable for use in damp places has a lead sheathing between the armor and the braided covering of the conductors, as shown at *a*, Fig. 20, and is practically as safe as conduit construction. The trade name for this type of cable is BXL, the letter L meaning lead-covered. Armored cable is recommended in preference to knob-and-tube work in completed frame buildings, both new and old, where there are a large number of circuits, as the cable can be installed with the least possible cutting of walls and floors.

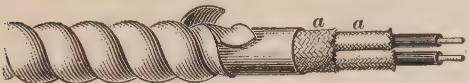


FIG. 20

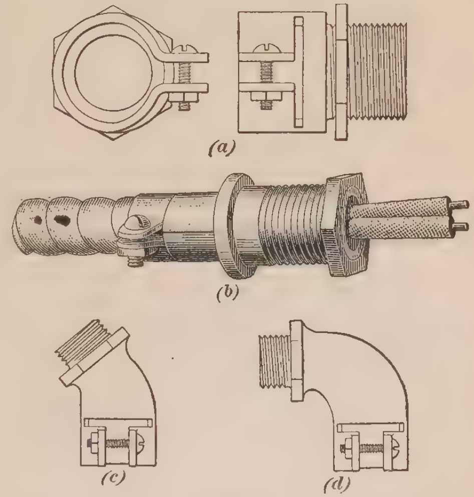


FIG. 21

29. The cable terminals must be securely fastened in outlet boxes, junction boxes, and cabinets, and the armor must be effectively grounded. Approved terminal fittings must be used, some of which are shown in Fig. 21. A malleable-iron panel-box connector is shown in (*a*), a stamped-steel connector in (*b*), a 45-degree connector in (*c*), and a 90-degree connector in (*d*).

MISCELLANEOUS FITTINGS AND ACCESSORIES

LAMP SOCKETS AND RECEPTACLES

30. A **lamp socket** is a lamp-holding device designed to be fastened to a threaded pipe (as on fixtures) or hung on wires (as a pendant). A **lamp receptacle** is a lamp-holding device designed to be attached to a flat surface or within a box by a screw or clamping ring. **Sockets** are made with shells of metal (usually brass), porcelain, or molded composition. Metal-shell sockets can be obtained in any finish that can be applied to metal.

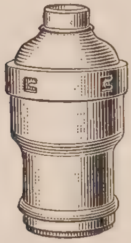


FIG. 22

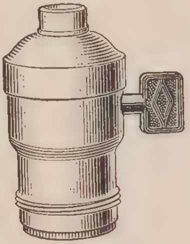


FIG. 23

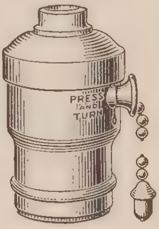


FIG. 24

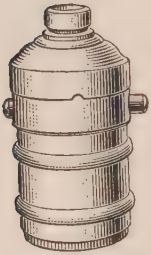


FIG. 25

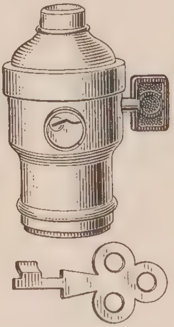


FIG. 26

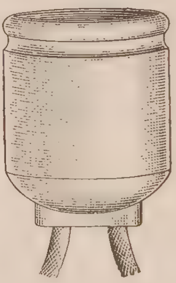


FIG. 27

31. Several forms of metal lamp sockets are in common use. A keyless socket is shown in Fig. 22, a key socket in Fig. 23, a pull socket in Fig. 24, a push-button socket in Fig. 25, and a locking socket in Fig. 26. The keyless socket is the cheapest and is suitable wherever the current need not be controlled at the socket. The locking socket serves to lock the lamp so that no one without the key can remove it. Porcelain sockets are also available in each of these types, and should be used whenever they may be handled with wet hands, as in bathrooms, kitchens, and laundries. Weather-proof sockets, as shown in Fig. 27, are prescribed by the Code rules for damp places.

32. Receptacles are usually made with shells of porcelain, or of brass with a porcelain base. In Fig. 28 (*a*) and (*c*) are shown examples adapted to special fittings for exposed conduit work. In (*b*) a special type of receptacle is shown mounted in an outlet box. The groove in the neck of each of these receptacles provides a means of attaching to it a lamp-shade holder. A useful receptacle, combining the functions of socket and canopy, and furnished with a pull switch, is shown in Fig. 29. This type is useful for overhead lighting in rooms with low ceilings and in corridors where few lamps are necessary. A keyless receptacle for exposed wiring is

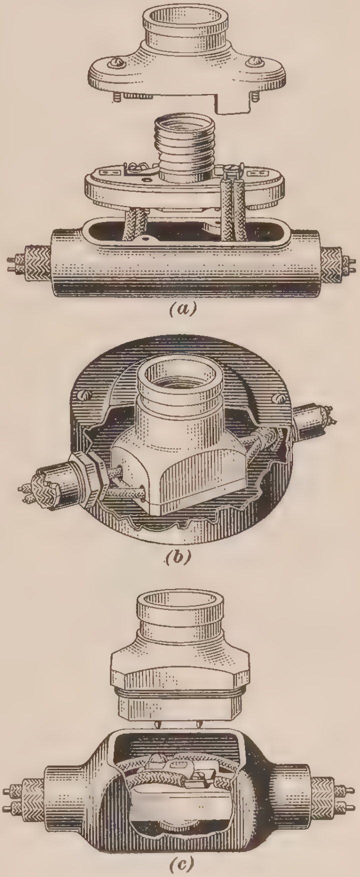


FIG. 28

illustrated in Fig. 30. As receptacles are not adapted to mounting on fixtures, their use is more limited than that of sockets. They find their chief applications in exposed work such as sign lighting, show-window lighting, and decorative lighting.

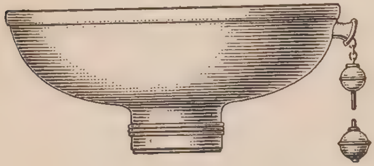


FIG. 29

33. In garages, oil refineries, chemical plants, and other places where inflammable vapors or gases may exist, a lamp and its socket or receptacle should be protected by a vapor-proof globe fitted air-tight in a suitable cap or in a reflector as in Fig. 31. If the wiring is exposed, the lamp and its accessories should be supported from a piece of rigid conduit enclosing approved rubber-covered wire. The wires should be soldered directly to the circuit and, if moisture is present, the upper end of the conduit should be sealed with insulating compound.

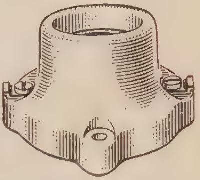


FIG. 30

As regards size, lamp sockets and receptacles can be divided into three general classes: small, medium, and mogul. The small sockets are those used with candelabra and miniature lamps. The medium sockets are for the ordinary Mazda lamps. The mogul sockets are for street lamps and high-candlepower gas-filled lamps.

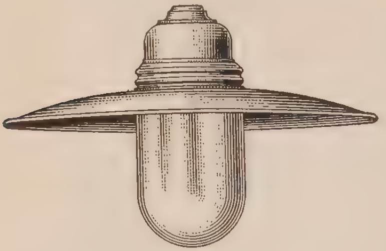


FIG. 31

PANEL-BOARDS AND CABINETS

34. As previously mentioned, circuit work usually begins at a central place called a center of distribution, at which are installed switches for the control of the circuits and automatic cut-outs for the protection of the circuits. The switches and cut-outs are assembled on what is variously called a distribution board, a cut-out panel, a tablet board, or a panel-board, and are enclosed in a cut-out box, a panel box, or a panel-board cabinet.

35. The term *cut-out box* is usually applied to boxes designed for surface mounting and accommodating only a few circuits, but it is also used frequently to designate the smaller and cheaper forms of boxes used in concealed work. A simple form of cut-out box for a small installation of concealed knob-and-tube work is shown in Fig. 32 (*a*). Porcelain blocks bearing base fuses and switches are mounted in a wooden box lined with asbestos or metal. The mains and the branch circuits are led into the box through porcelain tubes. The finished box has a wooden door lined with fireproof insulating material, such as slate or asbestos board, and is finished on the outside as shown in (*b*).

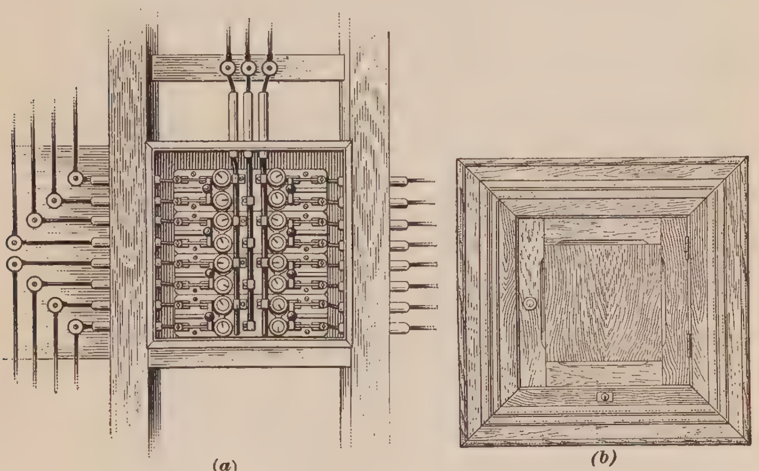

(*a*) (*b*)

FIG. 32

36. A slate panel-board on which switches and cut-outs are mounted, is shown in Fig. 33. This board provides for ten branches from two-wire mains. The mains are connected to the lugs at the bottom of the board and clips are shown for the main fuses that will connect the lugs with the vertical bus-bars, from which branch circuits, each identified by a number, are taken through switches and fuses. Panel-boards are made in many designs, depending on the service for which they are intended. In very large installations it is generally necessary to have panel-boards made to order.

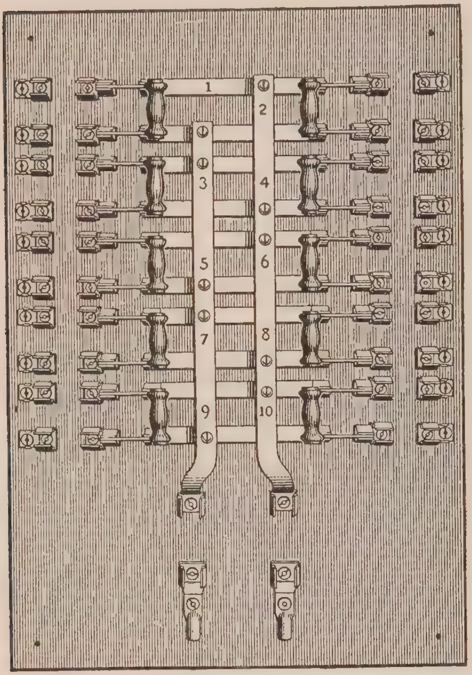


FIG. 33

37. In Fig. 34 is shown a panel-board mounted in its cabinet. The branch circuits are connected through knife switches *a* and enclosed fuses *b* to the bus-bars *c*, which receive current from mains led to the cabinet in the conduit *d*. The branch circuits are of twin wire carried in conduits *e*. Cartridge fuses *f* protect the mains. The lining *g* of the gutter, which serves as a wiring compartment, is of $\frac{1}{16}$-inch enameled iron. The barriers, or inner sides of the gutter, surrounding the panel-board, are of $\frac{1}{2}$-inch slate, of which material the board is also made. The complete cabinet has a door of steel which is sometimes lined with slate. This door swings on a removable frame, or trim, that covers the gutter.

38. In Fig. 35 (*a*) is shown a cut-out panel provided with specially designed push-button switches to eliminate trouble due to improper operation of knife switches. In (*b*) the doors and casings are shown in place. The doors are so arranged that the fuse compartment may be kept locked, while any one can have access to the switches. The lugs, bus-bars, etc., of panel-boards should be of copper; the number of joints, or connections, between the mains and branch-circuit wires should be reduced to a minimum, and the fuses, clips, and connectors should be of ample carrying capacity and mechanical strength.

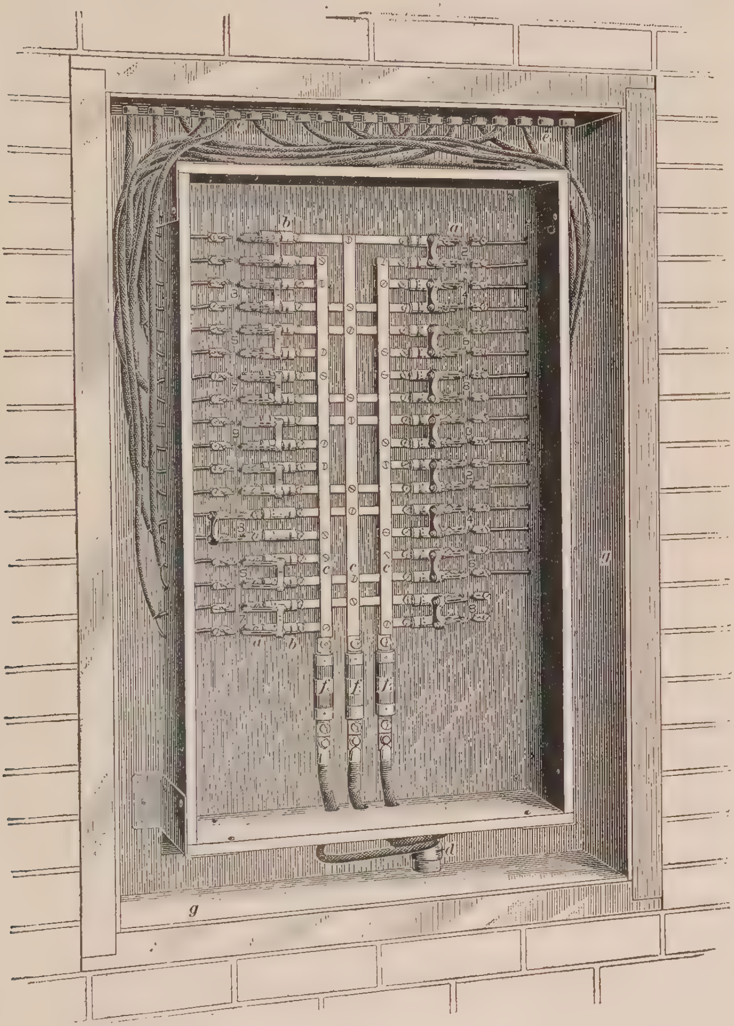
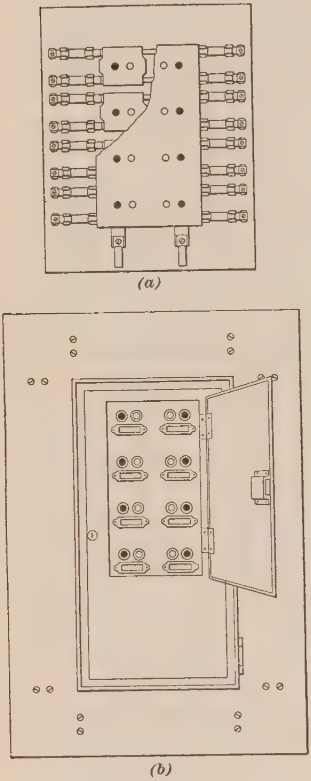


FIG. 34

39. Panel-boards having toggle, or tumbler, switches, as shown in Fig. 36, to control the main and branch circuits, are also extensively used. Wooden cabinets are permitted with knob-and-tube work, and with wooden molding, but they are not allowed with iron conduits, armored cable, or metal molding. When wooden cabinets are used they must be lined with approved non-combustible material and preferably covered on the outside also. It is good practice to secure to the inside lining of the cabinet door a frame in which can be placed a schedule, or directory, of the various branch circuits and location of the lamps that they supply. The schedule also gives the proper sizes of fuses for the feeders, mains, and branches.


(a)

(b)

FIG. 35

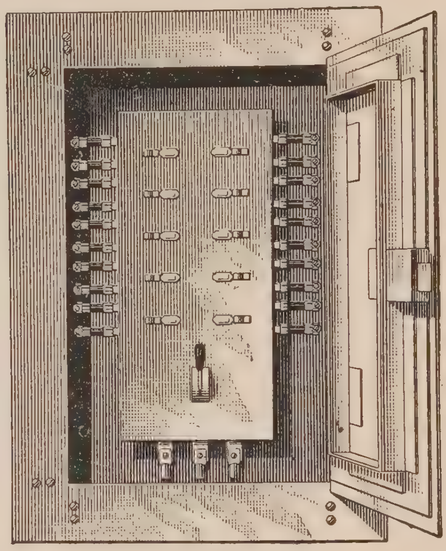


FIG. 36

FIXTURE SUPPORTS

40. Supports are installed to carry the light fixtures. For fixtures supplied only with electric current a fixture stem or stud of the type shown in Fig. 37 is generally used in both wall and ceiling outlet boxes, to which the fixture may be connected. Where heavy ceiling fixtures are contemplated, however, a special hanger, called the *Hickey fixture hanger*, as shown in Fig. 38, is generally installed. Supports made of gas pipe are sometimes used for this same purpose and are formed and installed as shown in Fig. 39 (*a*) and (*b*). Fixtures to be supplied with gas are usually supported by the gas-pipe fittings.

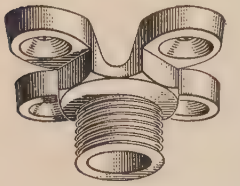


FIG. 37

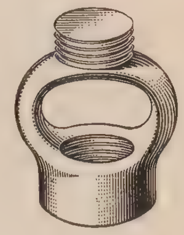


FIG. 38

41. Insulating joints should be used when fixtures are supported at outlets in metal-conduit, armored-cable, or metal-molding systems; fixtures should also be insulated from gas piping or any grounded metal work, from metal walls or ceilings, from plaster walls or ceilings containing metal lath, and from walls or ceilings in fireproof buildings. An insulating joint that may be used for a combination gas and electric fixture is shown in Fig. 40.

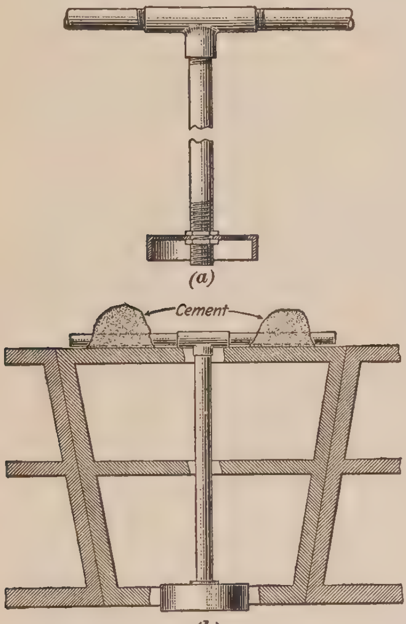


FIG. 39

An application of an insulating joint to a combination gas-and-electric fixture supported from the gas pipe is shown in Fig. 8. The ends of the conduit at the points where they enter the outlet box *a* are provided with insulating nipples *b*, and the gas pipe *c* at the point where it passes through the box is protected by an insulating sleeve *d*, as required by the Code. The loop *e* of twin conductors is brought down from the conduit, and the fixture wires are connected to it, as shown. As required by the underwriters, a canopy insulating ring is placed between the fixture canopy and the ceiling, if the ceiling or the lath is metal.

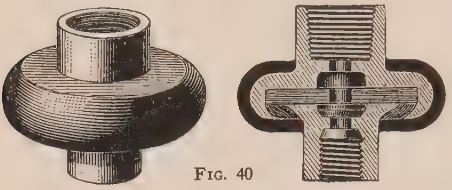


FIG. 40

TRANSFORMERS, SERVICE ENTRANCES, SWITCHBOARDS, AND METERS

TRANSFORMERS

42. If the current is alternating, it is usually transmitted on the line wires from the central station at a voltage too high for the wiring in the interior of a building, and transformers must be installed near the building to reduce the voltage. The company from which the power is purchased generally supplies and installs the transformers. The preferred location for transformers is outside the building for which the power is purchased, possibly on a nearby pole or in a small isolated building for transformers only, or possibly in an outdoor enclosure. The transformer may also be fastened to the outer wall of the building, or installed in an outside vault, as shown in Fig. 41. The rules and regulations of the Code govern the manner of constructing these vaults, and should be referred to before proceeding with any of this work.

Transformers in buildings may be installed only with special permission of inspection bureaus. They must be located as closely as possible to the point at which the primary wires enter the building, and must be placed in a fireproof room used for no other purpose. The transformer room, or enclosure, must be practically air-tight, except that it must be thoroughly ventilated to the outside air, preferably through a chimney or flue, and the floor provided with a cesspool and drain. The equipment required for the entrance to a transformer room is shown in Fig. 42.

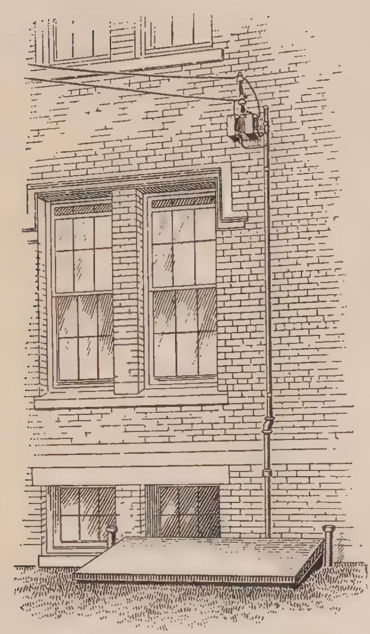


Fig. 41

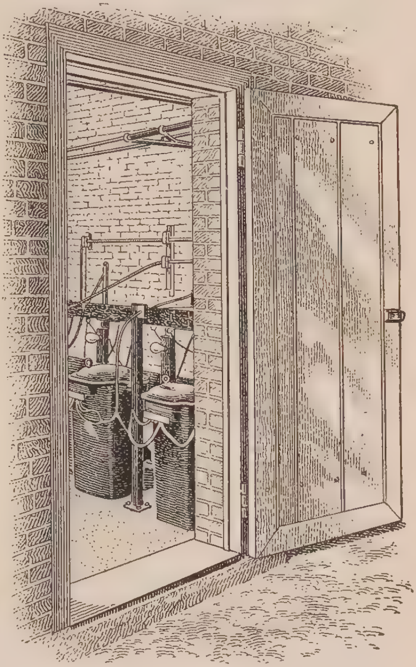


Fig. 42

SERVICE ENTRANCES

43. The location of a service entrance to the building depends on the location of the light-and-power company's mains. The architect should, therefore, confer with a representative of the power company relative to these mains before he determines upon the location of the service entrance or the transformer room, and he should provide for their installation in his electrical specification. This will permit the architect to make provision for openings in the foundation walls, through which the service lines may be brought after the wall has been completed.

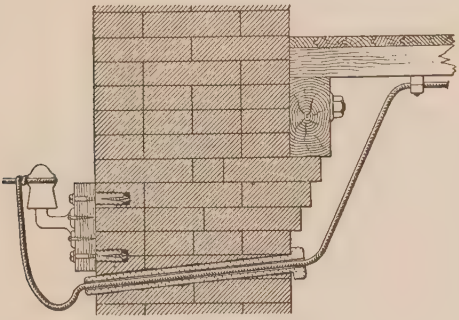


FIG. 43

44. Examples of service entrances from overhead mains are shown in Figs. 43 to 45. In the first installation the wires enter the building through a porcelain tube inclined toward the outside of the wall in order to prevent the entrance of water. In the second the wires enter through a pipe conduit by way of a special service head. In the third the leads enter the basement of a residence in a conduit provided with a special service head *a* and a special elbow *b*.

45. When an owner objects to the carrying of overhead wires to his building, and he is willing to meet the extra expense, arrangements can generally be made with the lighting company to bring the service leads underground from a nearby pole. The installation of the underground cable can be made by the company or by the electrical contractor working under the company's direction; in either case the final work of connecting the wires to the overhead mains will be done by the company.

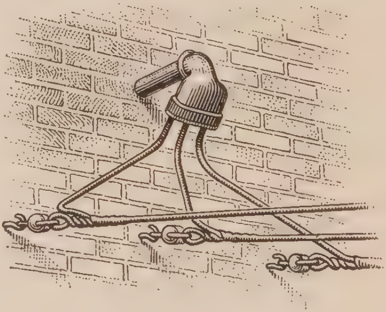


FIG. 44

46. Underground distribution mains are usually encountered in the down-town, or business, districts of the larger cities. Access to the underground system is obtained by means of manholes located at street intersections and at necessary intermediate points. In the manholes are installed junction boxes by means of which the customers' service leads are connected to the company's mains. Underground service leads, therefore, necessarily begin at a manhole, and enter the building through the basement wall. The switchboard and the wiring shaft should be located close to the service entrance to simplify the wiring system, and to reduce the cost of the installation.

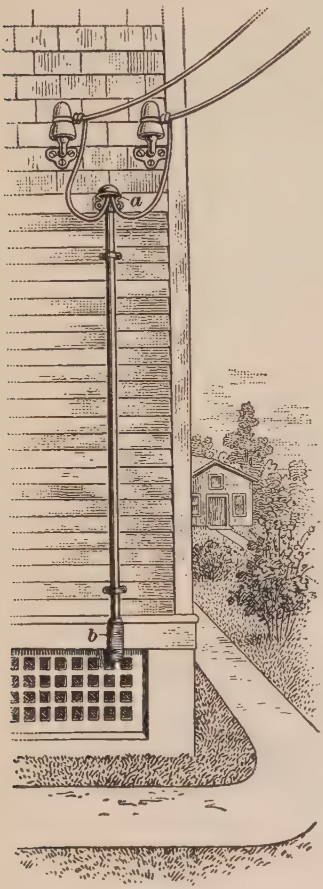


FIG. 45

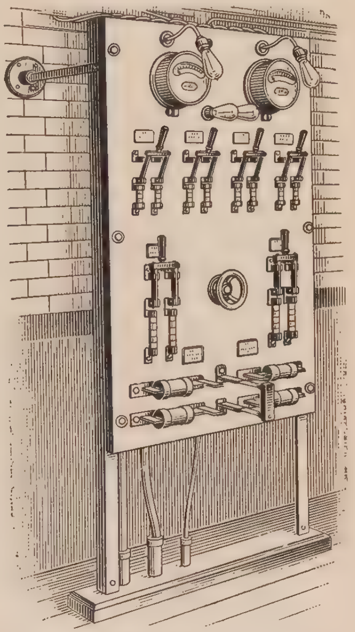


FIG. 46

SWITCHBOARDS

47. Typical switchboard construction consists of slate or marble slabs, or panels, mounted on vertical frames of pipe or angle iron. A switchboard may consist of one panel, as shown in Fig. 46, or it may have a series of panels as shown in Fig. 47. The number of panels depends on the size and nature of the distributing system to be controlled at the board. The front of the board usually bears only the equipment such as circuit-breakers, switches, fuses, instruments, etc., that must be easily accessible for operating the system, and this equipment should be neatly arranged and installed. The connection of the wires to the board should be made from the back, and ample space should be allowed at the rear of the board for this purpose.

48. The design of the switchboard and its location in the building should be left to the electrical engineer; the architect should, however, know that switchboards for general use are arranged in three divisions, lighting panels, power or motor panels, and either generator panels or service panels. Generator panels are required when the equipment comprises an isolated generating plant; and service panels, when energy is received from an outside source. Either of these panels serves to collect the current from the source and pass it to the

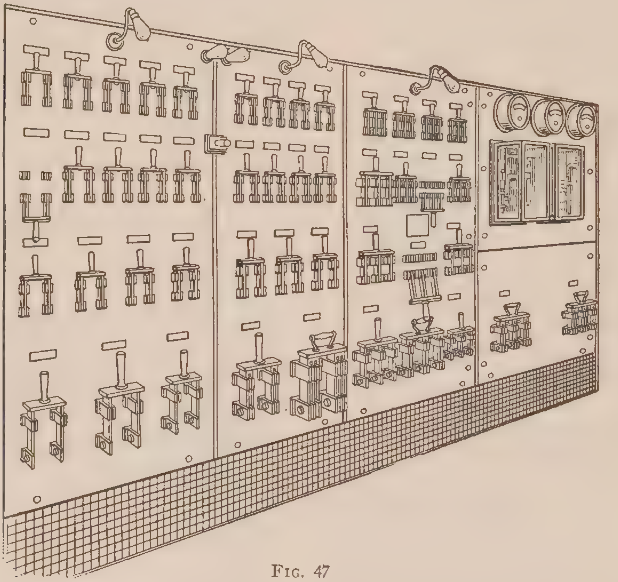


Fig. 47

other panels which, collectively, are called *distributing panels.* Switchboards are made in such a variety of sizes and kinds that for ordinary requirements they may be selected from manufacturers' catalogs, combining boards of the various types as required. When a switchboard of special design is required, it is necessary to consult the manufacturer and explain in detail what is required.

METERS

49. The watt-hour meters necessary to register the quantity of electricity used are generally provided and installed by the central station company. The electrical contractor arranges his wiring and provides and erects the meter boards according to the requirements of the company. When the meters are to be located on switchboards, it is necessary to obtain templets of such meters from the electric company, and send them to the manufacturer so that he may design and drill the switchboards to accommodate the meters. The meters remain the property of the central-station company. In office buildings, meters should be located in meter closets or other central places that are accessible. In residences and apartments they should be located in the basement or service part of the building where they may be read without annoyance to the owner or tenant. The last rule applies to office buildings and apartment houses in which the tenants pay their own electricity bills, or in which it is desirable for any reason to keep separate the amounts of electricity used.

HEAT, POWER, AND SPECIAL LIGHTING

ELECTRIC HEATING

50. Heat from electrical energy can be used for any purpose, but the great drawback to its use for general heating purposes is its expense. In residences electric heat gives the greatest service in portable appliances. A list of these appliances that are adapted to household use is given in Table II. When the architect is preparing plans for the electric work, he should confer with the owner of the building, to learn what devices are contemplated, and also what devices might be desired at some future time, so that circuits and switches may be provided and installed for both immediate and future requirements.

TABLE II

HOUSEHOLD ELECTRIC HEATING DEVICES

Appliances	Watts
Broilers, Three-heat	300 to 1,200
Chafing dishes, Three-heat	200 to 500
Cigar lighter	75
Coffee percolators	100 to 500
Corn poppers	300
Curling-iron heaters	60
Double boilers, Small	100 to 500
Flatirons, 3-pound to 9-pound	275 to 610
Foot warmers	50 to 400
Frying kettles, 8-inch	825
Griddles	330 to 1,500
Heating pads	50
Kitchenettes (average)	1,500
Milk warmers	450
Ornamental stoves	250 to 500
Ovens	1,200 to 1,500
Plate warmers	300
Radiators	700 to 6,000
Ranges (depending on capacity)	1,000 to 7,200
Shaving mugs	150
Stoves (depending on size)	50 to 1,500
Toasters (depending on size)	330 to 1,500
Urns, 1 to 5 gallons	110 to 1,700
Waffle irons (for 3 waffles)	1,150

51. Flatirons, percolators, and ranges are extensively used, and special provision should be made for these appliances. Mangles should also have a separate circuit when the rolls are heated by electricity. Where several irons are to be used simultaneously, it is necessary to provide a special circuit.

52. The use of electric energy for the continuous heating of rooms is usually confined to those localities served by water-power developments, whereby electricity can be generated very cheaply, or to places where cost is a relatively unimportant item in comparison to cleanliness and convenience. Small electric heaters are used quite extensively as auxiliaries to ordinary hot-air, hot-water, or steam systems, the electric heaters being employed temporarily in places such as bathrooms or bedrooms when the main heating plant is idle. The heaters most generally used for this purpose are of the portable type, an example of which is shown in Fig. 48.

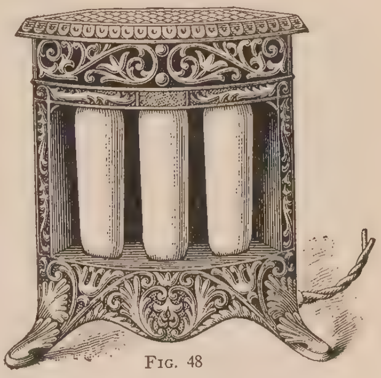


FIG. 48

53. The heating of water electrically can be accomplished by either of two general methods, the instantaneous system or the storage system. With the instantaneous system the heater current is turned on simultaneously with the opening of the faucet, and the water is heated to the required temperature as fast as drawn. The storage system employs a tank wherein the water can be either heated or stored, or both. Both of these systems operate practically the same as the corresponding systems equipped with gas heaters.

54. The wiring for electric heating depends, of course, on the nature and capacity of the equipment. The Code does not require a separate circuit for a device taking less than 660 watts, but when a heater is connected to a lighting circuit, the total load on the circuit must not exceed 660 watts. Practically interpreted, it means that a separate heating circuit must be run for every heating appliance of over 500 watts. Each heater or group of heaters of more than 660 watts capacity must be protected by a cut-out and controlled by a switch or a plug located within sight of the heater, and plainly indicating whether the current is on or off. These rules determine the number of heating circuits, and also the location of the heater switch.

55. The rule regarding heater switches sometimes requires the installation of a pilot lamp to indicate whether the heating switch is open or closed. An ordinary incandescent lamp properly connected to a knife switch fulfils the requirement, but a neater job is obtained by the use of a push-button switch of the proper rating and a small lamp mounted behind a red bull's-eye in a flush wall plate. For extension circuits, manufacturers make outlet assemblies comprising an extension-plug receptacle, a push-button switch, and a pilot lamp, all mounted together behind a wall plate, as in Fig. 49. No other safety precautions are necessary for heating devices, except that special heater cord, as prescribed by the underwriters, should be used for portable appliances.

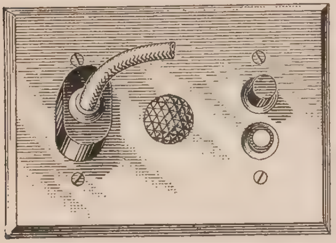


FIG. 49

56. In most cities the central-station rate for heating is lower than that for lighting, so that separate meters and wiring systems are necessary for the two. The circuits for heating current are generally led to comparatively few points in the building where heating appliances are to be used. The double system of wiring and metering is avoided in some localities where the central-station rate is sharply reduced after the consumption passes a certain quantity each period. This predetermined quantity is the estimated amount of energy which will be used for lighting.

ELECTRIC MOTORS

57. The selection of motors for the various requirements of a building should be referred to the electrical engineer, also the selection of the devices that form the motor auxiliaries and the wiring installed to conform with the special requirements of the motor and the device selected. Some makes of washers take a very large starting current, so that a circuit with a capacity of 20 amperes or more should be provided.

58. For general information, Table III is given to show the various application of motors and also as a reminder in making the plans for the electrical equipment. Some of the motor auxiliaries that are required are a starting device, a main knife-blade switch, a circuit-breaker, or fuse, and a starting-device panel-board. The starting devices may be hand-operated, semiautomatic, or automatic. The semiautomatic

TABLE III

MOTOR-APPLICATION REMINDER

Elevators
Escalators
Dumb waiter
Sidewalk lifts
Freight hoist
Blowers
Exhaust fans
Ventilating fans
Portable fans
Fire pump
House pump
Air (pressure) pump
Vacuum pump (cleaner)
Mechanical refrigerator
Laundry machinery
Package conveyers
Workshop (residences)

Dish washers
Portable tools
General utility
Ice-cream freezers
Dough mixers
Meat choppers
Knife cleaners } Hotels and restaurants
Pitcher cleaners
Grinders
Sewing machines
Addressing machines (offices)
Paper cutters (offices)
Printing machines (offices)
Dental machines
Electric sweepers
Washers
Mangles

control is similar in action to the remote control, in that it is operated by means of a pilot switch placed at a distant point. The automatic control is similar to the semiautomatic except that the operating current is controlled by a mechanical or electro-mechanical switch which may be controlled by air pressure, by water pressure, by the rise and fall of a float, etc. The switches, circuit-breakers, fuses, and panel-boards are of the same character previously described for regular electric equipments.

59. Small portable motors for household use range in size from $\frac{1}{20}$ to $\frac{1}{4}$ horsepower. These motors can be operated from a lamp socket provided the combined motor load and lamp load on the circuit does not exceed 660 watts. But, for the sake of convenience, it is well to provide extension-plug receptacles at desirable points in a building for this purpose. These receptacles should be on branches separate from the lamp circuits.

ELECTRIC SIGNS AND DISPLAY LIGHTING

60. Electric signs or devices for the illumination of the exterior walls of a building are rarely included in the original plans of the building. However, if the building is located in a zone where outdoor advertising may be desirable in the future, the architect should provide one or two 2-inch conduits for circuits leading from the main switchboard to the roof, through which wires may be pulled later. Where this illumination has been determined upon, the architect should confer with the representative of the advertising agency that is to lease the space and erect the devices, in order to secure the exact data required.

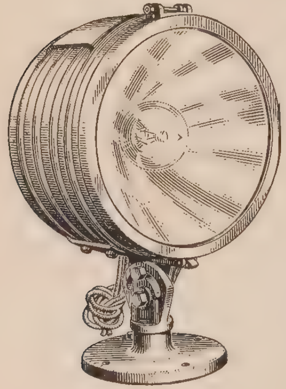


Fig. 50

One form of exterior illumination for a building is called *flood lighting* and consists of directing rays on a building from gas-filled mazda lamps located some distance from the building and mounted in a projector or reflector as shown in Fig. 50.

61. Show windows that are to be illuminated should have the lamps connected to special cut-out panels supplied from special feeders, because these windows are frequently lighted at hours when the remainder of the building is dark. In addition to the outlets for permanent show-window fixtures, it is well to have attachment-plug receptacles for connecting portable lamps, decorative lamps, and mechanical advertising devices. Extreme care should be taken that the wiring and fixtures in show windows are installed in accordance with the Code to avoid danger from overheated lamps or wires.

LOW-VOLTAGE WIRING

LOW-VOLTAGE SYSTEMS IN GENERAL

SOURCES OF LOW-VOLTAGE ENERGY

62. Definition and Classification.—The expression *low voltage wiring,* as used in this Section, refers to voltages ranging from 10 to 30, as used for signal, alarm, and bell wiring, although the underwriters define a low-potential system as one operating at 600 volts or less.

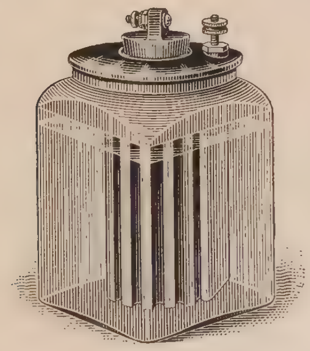


FIG. 51

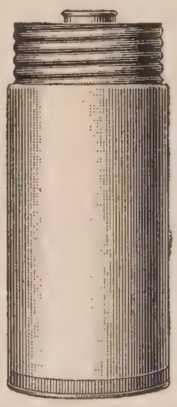


FIG. 52

63. Primary batteries are classed according to construction as *wet batteries* and *dry batteries*. Of wet cells the ordinary sal-ammoniac cell as shown in Fig. 51 is one of the most widely used. Because of their greater convenience and adaptability, dry cells are replacing wet cells for the smaller open-circuit system. The dry cell works on practically the same chemical principle as the sal-ammoniac cell, the essential difference being that the former is non-spillable. The dry cell is familiar to every one; a convenient type has a screw top, as shown in Fig. 52, similar to the base of an Edison lamp, and

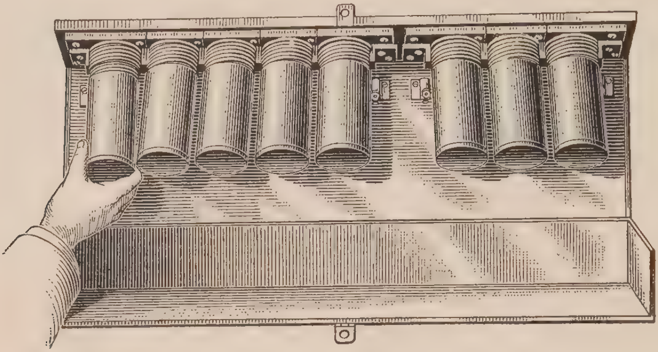


FIG. 53

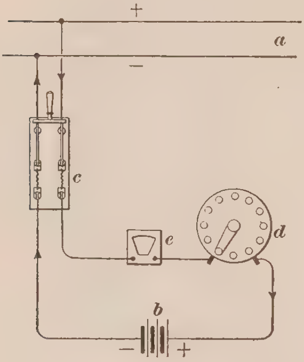


FIG. 54

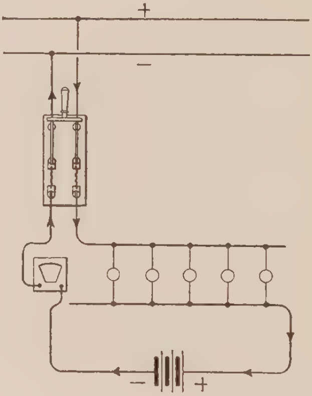


FIG. 55

can be screwed into a receptacle in a cabinet of special design, as in Fig. 53.

64. Storage Batteries.—The installation of a storage battery may be advisable in a building where many low-voltage devices are to be used, as in a hotel. With it must be the necessary switches, resistors, and regulators for recharging. Storage batteries are rated in ampere-hours, the product of the discharge rates in amperes and the number of hours that rate will be maintained without material decrease if the battery is fully charged at the outset. For example, a battery that will discharge 5 amperes steadily for 8 hours through a circuit of fixed resistance is a 40-ampere-hour battery.

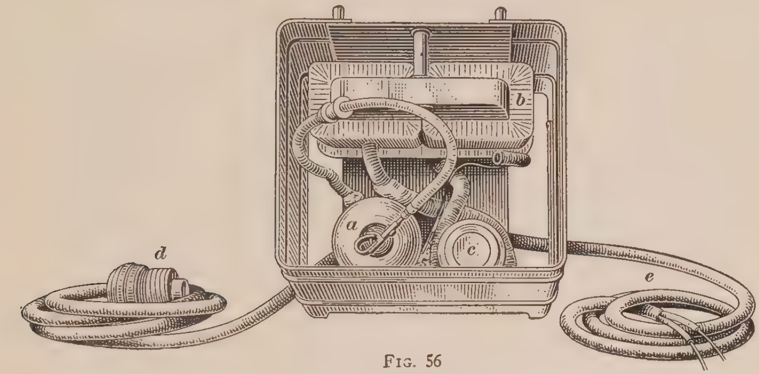


FIG. 56

65. When the voltage of a storage battery begins to fall rapidly, the battery is said to be discharged, and it must be recharged before further use. A small battery can be charged from a direct-current lighting circuit by connecting an adjustable resistor in series with the battery to regulate the charging current. Fig. 54 shows typical connections; the lighting circuit is represented at *a*, the battery at *b*, the switch at *c*, the adjustable resistor at *d*, and an ammeter at *e*. A group of electric lamps, forming a *lamp bank*, can be used for a resistor, as shown in Fig. 55, and the current can then be regulated by screwing in or out of their sockets one or more lamps.

66. If the lighting current is alternating it must be converted, or rectified, for charging a battery. For a small battery a tungar rectifier, Fig. 56, may be used. It consists of a rectifier bulb *a*, a compensator *b*, a fuse and receptacle *c*, alternating-current leads *d*, and direct-current leads *e*. The bulb is shown separately in Fig. 57, a tungsten filament being shown at *a*, and an anode consisting of a piece of graphite at *b*. A diagram of the connections is shown in Fig. 58. When using the rectifier, care must be taken to see that the direct-current leads are properly connected to the battery terminals according to polarity, and the plug on the alternating-current leads may then be screwed into a socket on a circuit of the right voltage. Large batteries are sometimes charged by means of motor-generators, each consisting of an alternating-current motor driving a direct-current generator.

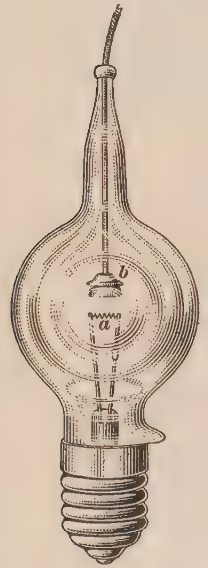


FIG. 57

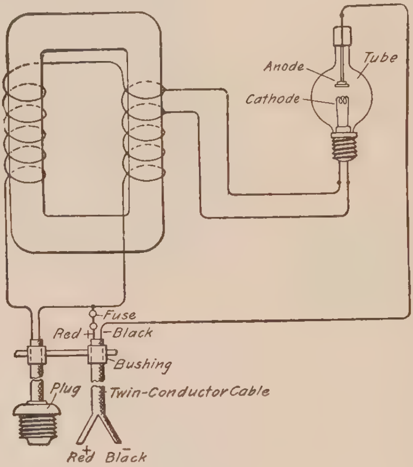


FIG. 58

67. Low-Voltage Alternating-Current Devices.—House bells and other low-voltage devices may be operated by alternating current, which can be obtained from the lighting circuits by the use of bell-ringing transformers.

GENERAL REQUIREMENTS FOR LOW-VOLTAGE WIRING

68. Installation Requirements.—Because of the low voltages and small currents carried by signal and alarm circuits, the conductors need not be so large nor so thoroughly insulated as those in power-and-lighting work. Yet, owing to the lack of strength of the small conductors and to the large number necessary in the more complicated systems, low-voltage wiring should be planned as carefully as light-and-power work. In dry wood-frame buildings the joists should be bored and the wires run through them. No protection except the insulation is necessary in this class of work. Metal staples, even when insulated, sometimes corrode the wires. Where wires are run open they can be fastened directly on the framing by means of fiber or compressed-wood cleats, insulated nails, or staples with an insulating saddle. Holes are cut at desired points and the wires brought out to push-buttons, bells, or other appliances. In finished buildings of wood-frame construction, the wires can be fished between the studs or joists or run along picture molding or the tops of baseboards. Concealed signal wires should not be fastened with metal.

69. In fireproof buildings, with no available hollow spaces, complete conduit or duct systems are installed within which are placed the wires of the low-voltage circuits. Low-voltage circuits cannot be run in the same conduits with lighting circuits. Where a conduit system is laid out, suitable outlet boxes or conduit fittings similar to those used for lighting work are provided, and pull boxes or junction boxes are installed where necessary. Also interconnection boxes, or cabinets, containing interconnection boards are installed at junction points.

70. Conductors for Low-Voltage Wiring.—For small low-voltage lines in dry places in wood-frame buildings wires with a paraffined double-cotton braiding can be used. For damp places in such buildings and for small lines originating at interconnection boxes in larger installations, braided twisted pairs with rubber insulation are used. Where a comparatively large number of wires must follow the same run, it is better to employ cotton-, silk-, or paper-insulated conductors twisted together in pairs and covered with an outer wrapping and a sheathing of lead. Conductors with cotton or silk insulation are generally used for cables of medium diameter and length, and paper-insulated conductors for larger cables such as telephone cables.

SIGNAL APPLIANCES AND SIMPLE BELL SYSTEMS

BELLS AND SWITCHES

71. Electric bells are of two general classes, vibrating bells and single-stroke bells. A **vibrating bell** is one with a hammer or tapper that vibrates as long as the bell receives current. A **single-stroke bell** is one that gives only a single tap, no matter how long the bell circuit is kept closed. A **continuous-ringing relay,** or **drop,** is a device connected in the circuit to a vibrating bell in such a manner that the bell continues to ring after the push button has been released by the operator. The bell rings until the relay is reset.

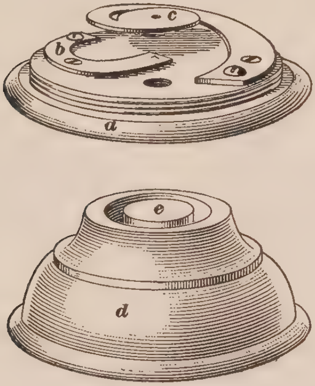


FIG. 59

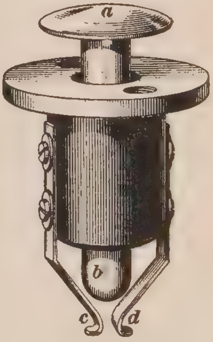


FIG. 60

72. An **electric horn** is a device with a metal diaphragm arranged to be set into vibration by electromagnets or by an electric motor. They are most commonly used on automobiles, but they are also used to some extent to replace whistles in factories. An **electric whistle** is a valve electromagnetically operated to control the passage or air or steam to a whistle. An **electric buzzer** is essentially the same as an electric bell, except that the hammer and gong are omitted. A buzzer is used where the loudness of the bell is unnecessary, or might be undesirable.

73. Switches, commonly called *push buttons,* or *bell buttons,* for operating electric bells, buzzers, and other low-voltage devices are made in the forms shown in Figs. 59, 60, and 61. In Fig. 59 the base for attaching to a wall, table, desk, etc., is shown at *a,* the two contacts at *b* and *c,* the cap at *d,* and the button at *e.* In the floor-type button shown in Fig. 60 the button *a* can be depressed so that plunger *b* will close the circuit between the contacts *c* and *d.* In Fig. 61 is shown a button with a clamp for the edge of a table or desk. Bell buttons are available in groups so that several different signals may be given from one point, as from the desk of a manager or superintendent, who may wish to call an assistant.

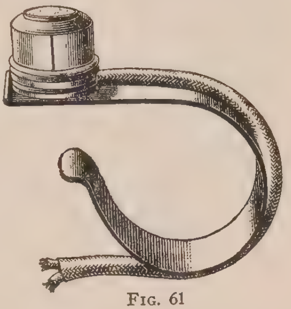


FIG. 61

CALL-BELL SYSTEMS

74. Call-bell systems are possible in many forms, varying from the simplest system consisting of one bell and one push button, to complicated systems including one bell and many buttons, or a multiplicity of both bells and buttons in the same system. The average dwelling has a bell that may be rung from the front or rear door, or possibly a separate bell or buzzer would be provided for each door. There is also usually a floor push button in the dining room, for ringing a buzzer in the kitchen.

75. In Fig. 62 is shown a push-button and speaking-tube mouthpiece in connection with a mail box. This type of fixture is commonly used in small apartment houses having no elevator service or lobby attendant. A visitor in the vestibule of the main entrance can ring a bell in the apartment he wishes to visit. When he has the attention of some one in the apartment, he announces himself through the speaking-tube. The person in the apartment then presses a button that sends current to an automatic electric door-opener in the frame of the inner door of the main vestibule. This door-opener releases the lock and allows the visitor to enter. Buzzer buttons may also be placed in the public hall on each floor of the house, so that the visitor may announce his arrival at the apartment door.

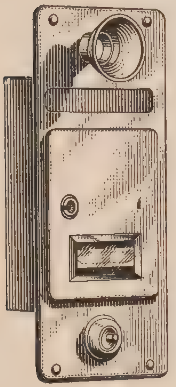


FIG. 62

ANNUNCIATORS AND THEIR USES

76. When one electric bell can be rung from any of a number of places, as from different rooms of a hotel or from different entrances to an elevator shaft, a device called an *annunciator*, Fig. 63, is installed to indicate the location of the person signaling. Annunciators depend on the movement of a pointer, drop, or shutter by the action of an electromagnet that receives current when the corresponding push button is operated.

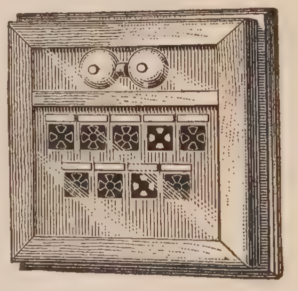


FIG. 63

77. A mechanical-reset annunciator as shown in Fig. 64 is one in which after every signal each indicator must be restored by hand to its normal position. This is done by manipulating a push rod at the bottom of the annunciator. Such an annunciator has two pronounced disadvantages; it must be mounted within reach and in a readily accessible place, and if the indicator is not reset promptly after each call, confusion is very likely to result.

78. In electrical-reset annunciators that are reset electrically the indicators are restored by pressing a key or a push button controlling a current through reset windings on the electromagnets. It must also be reset promptly after each call, but it can be mounted out of reach and reset from any convenient place. Automatic-reset annunciators are also operated electrically, but they require no manipulation on the part of an attendant, all indicators of previous calls being reset automatically by the last call which is the only call that indicates.

79. Return-call annunciators are provided with keys so that a person at either end of a line can be signaled that the call has been heeded. Such annunciators are useful in hotels having no interior telephone system and in any building, like an apartment house, having a speaking-tube system.

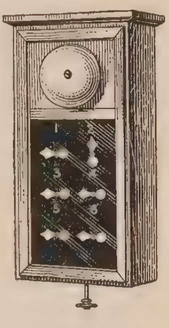


FIG. 64

80. In the lamp annunciator, the signaling station is indicated by the lighting of a small incandescent lamp. The system is wired so that the annunciator bell stops ringing as soon as the caller releases his push button, but the lamp burns until the call is answered.

81. A large number of passenger elevators are equipped with annunciators having small battery lamps instead of names or numerals. White lights are used to indicate floors from which passengers wish to ascend, and red lights indicate those from which they wish to descend.

BURGLAR-ALARM SYSTEMS

82. A burglar-alarm system includes essentially a source of electricity, a bell, an annunciator, and various devices placed about the building in such a manner that an intruder will make the system operative. The bell sounds the alarm and the annunciator indicates the location at which the intruder is trying to enter. Devices for detecting the entrance of a burglar are made in many forms adapted for various purposes. Some are designed to be operated by the raising of a window or by the opening of a door, where entrance is likely to be attempted.

Bells for burglar alarms should be either of the continuous-ringing type or controlled by a continuously-ringing relay. Otherwise, an entrance might be made so quickly that the bell would not ring long enough to arouse the occupants of the building.

FIRE-ALARM SYSTEMS

83. The fundamental fire-alarm system consists of a number of signal boxes from each of which the alarm bell can be sounded. A simple system well adapted to a small loft building with three or four floors, or to a one-story building with considerable floor area, is installed by placing on each floor or in each room or department a bell to give the alarm, and an annunciator to indicate the location of the station from which the alarm was sent.

84. The alarm boxes of larger systems are generally semi-automatic in operation. The turning of the key or the pulling of a small lever releases a clockwork mechanism propelling a contact maker or breaker, as the case may be. Each time the contact maker acts, the alarm bell is tapped once, and the number of the station is thus signaled. For example, two taps, a pause, and then three taps is the signal from station No. 23. The box mechanism is automatically arranged to send the signal three times. The mechanisms of such boxes are arranged so as to be non-interfering. If persons at two different stations should start the mechanisms simultaneously, the signals would not conflict but would be received one at a time.

85. The fire-alarm system of the I.C.S. instruction building and printery, a typical modern installation, employs boxes working on the principle just described. Instead of a bell, however, the alarm consists of a whistle electrically operated. The system is connected to the city fire-alarm telegraph system, two outside circuits being run, one directly to a nearby engine house and the other to the city fire headquarters from which it is relayed to all battalion chiefs and companies that respond to alarms in the I.C.S. zone. In a locked cabinet, to which only the fire marshal or one of his lieutenants holds the key, is mounted a switch for making silent tests of the system or sounding an alarm for a fire drill. The test switch is wired so as not to operate the city alarms. Fire-alarm systems of this type are built for both direct and alternating current.

86. The so-called *thermostat systems* are automatic in operation. At various places in a building are thermostats or thermostatic switches, constructed so as to close automatically a circuit whenever the temperature reaches a dangerous degree.

MISCELLANEOUS LOW-VOLTAGE EQUIPMENT

ELECTRIC CLOCKS

87. A watchman's clock consists of an electromechanism so arranged that an electric current or impulse causes a mark to be made on a paper dial rotated by a clock movement. Watchman's stations are located in various places that the watchman is supposed to visit. The watchman carries a switch handle, or key, with which, at each station, as he visits them in regular order, he is enabled to send a brief current through the clock mechanism. The clock itself is usually located in the main office where the watchman cannot get to it. This furnishes a system by which the movements of the watchman may be known with certainty, for, if he fails to visit a station at the appointed time, the absence of a corresponding mark on the clock dial will expose his failure.

88. Electric uniform-time clocks are used in large establishments where it is desirable that the same time shall govern employes, guests, or tenants in a number of rooms or buildings. A master clock is located at a convenient place and at regular intervals, usually once each minute, operates an electric circuit that passes through a series of secondary clocks located wherever desired, and thus moves the hands of each clock in the circuit.

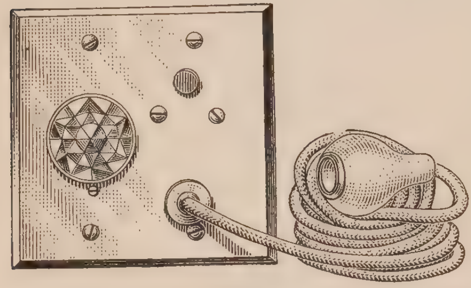


FIG. 65

NURSES' AND MAIDS' CALL SYSTEMS

89. Nurses' signal systems are used in hospitals to enable patients to call nurses. By pressing a button in a pendent switch extended from a special wall-plate, Fig. 65, a patient lights a lamp in an annunciator, Fig. 66, in the nurses' duty room, a corridor, Fig. 67, outside the door of the ward room, and another lamp in the wall-plate that is near the head of the patient's bed, and at the same time sounds a buzzer in the duty room and one in the diet kitchen. The system is non-interfering, as pressing a reset button extinguishes only those lamps that are controlled from the button operated by the patient. The buzzers sound only momentarily, but they sound each time the patient presses the bedside button. In a room with only one bed the lamp in the wall-plate can be omitted without causing inconvenience.

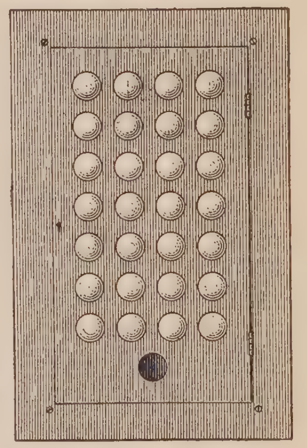


FIG. 66

90. Maids' location and call systems for hotels are arranged so as to inform the room clerk or the floor clerk as to the room or suite in which the maid is working. When a maid enters a room, she inserts a lamp in a special receptacle in the corridor wall near the door of the room. The lighted lamp informs any one in the corridor of the maid's location, and at the same time a circuit is completed that shows the room number on an annunciator at the desk of the room clerk or the floor clerk. Thus, if the services of the maid are required elsewhere at short notice, she can be called immediately over the house telephone.

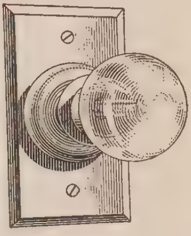


FIG. 67

TELEPHONE WIRING

TELEPHONE SYSTEMS IN GENERAL

91. Telephone equipment ranges, according to the nature and the size of the building, from a single instrument to several hundred. There are three general plans of connecting the instruments in a building requiring a number of telephones: the switchboard system, the intercommunicating system, and the party-line system.

92. A **switchboard system,** frequently called a private-branch exchange system, to distinguish it from the public-exchange system, includes a special telephone switchboard from which lines radiate to the various instruments, and at which are made the connections enabling persons to talk to one another. An **intercommunicating system,** sometimes called a house system, employs no central switchboard; switching devices located at each telephone station provide a means enabling a person at any station to call every other station on the system. The **party-line system,** as now commonly used, refers to the connection of from two to four subscribers on one trunk line from a public exchange, none of the subscribers being able to call another on the same party line, except through the central exchange. The **local-battery party-line** system, using a magneto for ringing and local batteries for talking, enable a person to call another without the assistance of the central station. The local-battery party-line system is now rarely installed except in rural districts.

93. The switchboard system is generally used in hotels or other large public buildings and for groups of buildings having a large number of telephones and consequently a large number of calls. The intercommunicating systems are very useful for internal service in residences, apartment houses, stores, offices, schools, banks, etc., in general, whenever the number of telephones is small and the calls infrequent. Telephone switchboards are of three fundamental types, manual, automatic, and semiautomatic. The choice among these three types is governed by the kind and size of the business to be served, and the problem is one to be solved by a telephone specialist. All the architect need know is the size and location of the switchboard, in order that he can, if necessary, make special provision for it.

TELEPHONE EQUIPMENTS AND WIRING METHODS

94. Residences.—Provisions for telephone wiring are seldom necessary in small residences because the one telephone generally used in each residence can be readily installed after the building is completed. Even in such a building, however, provision for telephone wiring may be made at small additional expense. For a large residence in which several telephones are to be installed, provisions for the telephone wires should be made in the design. After the locations of the telephones have been determined, the plans should be marked with the routes of the rigid conduits in which the wires are to be carried, and the location of the telephone outlets should be indicated as closely as possible. Floor outlets should be provided for portable, or desk, instruments. The cabinets of so-called flush-type instruments are set in the wall, and provision must be made accordingly. For a house system using not more than six telephones, $\frac{3}{4}$-inch conduit is large enough; in larger systems, the size of the conduit must be greater, because a pair of wires is in some cases required for each telephone.

95. Hotels, Apartment Houses, Etc.—In large buildings where extensive telephone service is to be installed, provision must be made for the wiring and for a switchboard. In a hotel the switchboard is usually located in or near the office. A pair of wires from each room or suite connect near the switchboard with a common center called a main terminal box. From the switchboard the trunk wires run to the point at which the telephone cable enters the building, generally in the basement. From the main terminal box, cables containing the twisted pairs are carried up vertical pipe-shafts to terminal boxes located on the various floors. From each of the terminal boxes a conduit system is run to designated locations in the rooms.

96. In apartment houses, where only one telephone for each apartment is required, a simple method of wiring is to carry a vertical conduit up through each tier of apartments, and to provide an outlet in each apartment. Individual twisted pairs of rubber-covered wire may then be pulled through this conduit for each telephone. The individual wires can be carried in a cable from the bottom of each riser to the switchboard, which is generally located in the main hall. Small apartment houses without hall attendance do not have telephone switchboards, but employ modifications of the intercommunicating system. In each vestibule is a vestibule set, or tradesmen's set, similar to the flush wall set shown in Fig. 68, comprising a transmitter (mouthpiece), a receiver, a nameplate for each apartment and one for the janitor, and a corresponding push button for connecting with any apartment or with the janitor's office. In the janitor's office is a similar equipment,

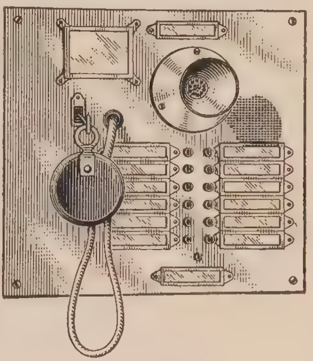


FIG. 68

together with an annunciator to show the janitor which apartment or which vestibule is calling. The apartment set, of which the flush wall instrument shown in Fig. 69 is an example, does not differ from the ordinary telephone except that it has a button for calling the janitor. Another type of apartment set has, in addition, a button for operating an automatic door-opener.

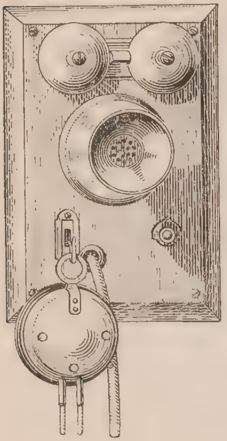
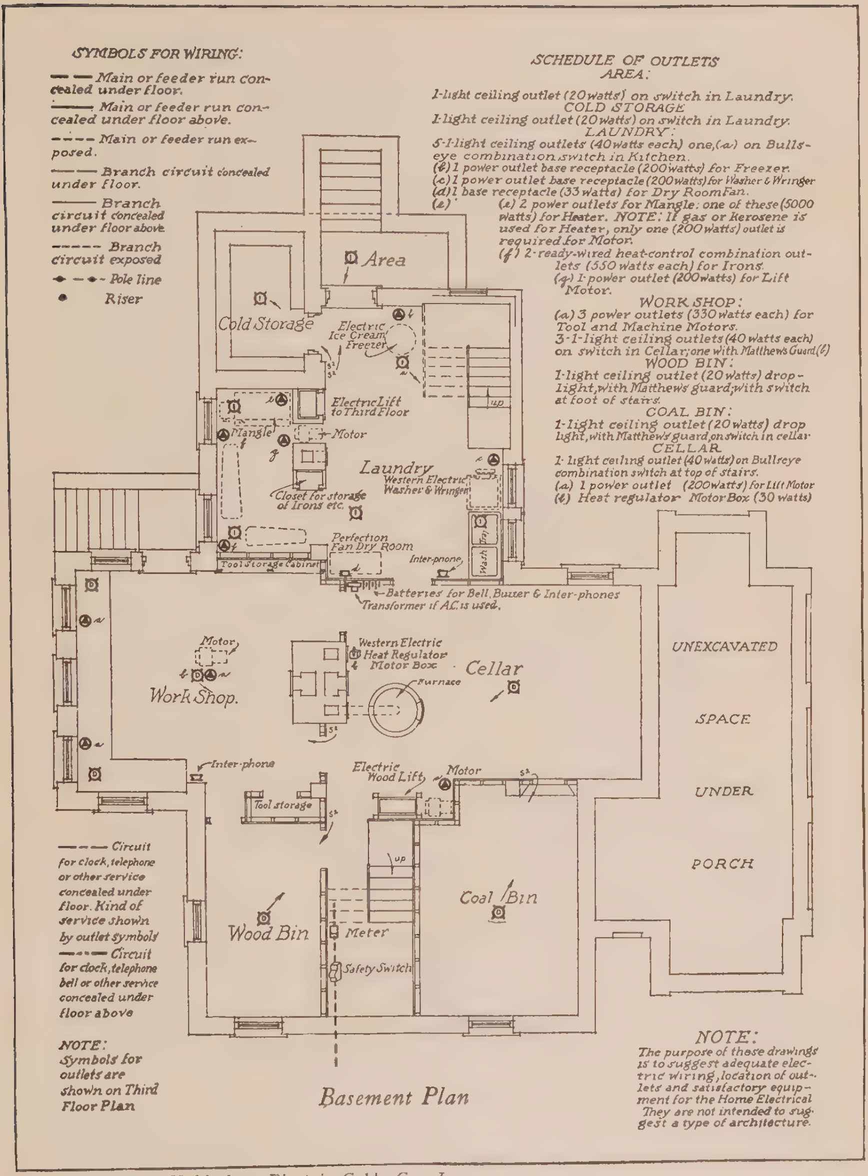


Fig. 69

97. Office buildings, department stores, and other large buildings usually have public-service telephone systems and are frequently very complex. It is customary for the architect to confer with the telephone company's engineer relative to the telephone requirements of the building and the service the company will give. By such a conference the best location of the wire shaft, distributing boards, junction boxes, and telephone outlets may be determined and the most effective system and consequent economical installation secured. The owner of the building will be required to provide all conduits and accessories, including cases for terminals, junction boxes, etc. The telephone company will provide and install the wiring, terminals, and the individual telephones.

98. In Figs. 70 to 73 are given plans of a dwelling house fitted up with all the electrical appliances that it is possible to show in such a house. It is not likely that these appliances would all occur in any one house, but the diagrams are given to show the application of such devices in fitting up a modern dwelling. The several appliances are indicated by symbols which, with slight variations, are those agreed on by the American Institute of Architects and the National Electrical Contractors' Association, but are subject to change and revision from time to time. These symbols are shown in Fig. 74.

The symbols shown in Fig. 74 are the ones most generally used at the present time. A new set of symbols, shown in


Area
Cold Storage
Electric Ice Cream Freezer
Electric Lift to Third Floor
Mangle
Motor
Laundry
Western Electric Washer & Wringer
Closet for storage of Irons etc.
Perfection Fan Dry Room
Tool Storage Cabinet
Inter-phone
Wash Tray
up
Batteries for Bell, Buzzer & Inter-phones
Transformer if A.C. is used.
Motor
Work Shop.
Western Electric Heat Regulator Motor Box
Cellar
Furnace
Inter-phone
Electric Wood Lift
Motor
Tool storage
up
Wood Bin
Meter
Safety Switch
Coal Bin
UNEXCAVATED SPACE UNDER PORCH

SYMBOLS FOR WIRING:

Main or feeder run concealed under floor.

Main or feeder run concealed under floor above.

Main or feeder run exposed.

Branch circuit concealed under floor.

Branch circuit concealed under floor above.

Branch circuit exposed

Pole line

Riser

SCHEDULE OF OUTLETS

AREA:

1-light ceiling outlet (20 watts) on switch in Laundry.

COLD STORAGE

1-light ceiling outlet (20 watts) on switch in Laundry.

LAUNDRY:

5-1-light ceiling outlets (40 watts each) one, (a) on Bullseye combination switch in Kitchen.

(b) 1 power outlet base receptacle (200 watts) for Freezer.

(c) 1 power outlet base receptacle (200 watts) for Washer & Wringer

(d) 1 base receptacle (33 watts) for Dry Room Fan.

(e) (e) 2 power outlets for Mangle: one of these (5000 watts) for Heater. NOTE: If gas or kerosene is used for Heater, only one (200 watts) outlet is required for Motor.

(f) 2-ready-wired heat-control combination outlets (550 watts each) for Irons.

(g) 1-power outlet (200 watts) for Lift Motor.

WORK SHOP:

(a) 3 power outlets (330 watts each) for Tool and Machine Motors.

3-1-light ceiling outlets (40 watts each) on switch in Cellar; one with Matthews Guard (b)

WOOD BIN:

1-light ceiling outlet (20 watts) drop-light, with Matthews guard; with switch at foot of stairs.

COAL BIN:

1-light ceiling outlet (20 watts) drop light, with Matthews guard, on switch in cellar

CELLAR

1-light ceiling outlet (40 watts) on Bullseye combination switch at top of stairs.

(a) 1 power outlet (200 watts) for Lift Motor

(b) Heat regulator Motor Box (30 watts)

Circuit for clock, telephone or other service concealed under floor. Kind of service shown by outlet symbols

Circuit for clock, telephone bell or other service concealed under floor above

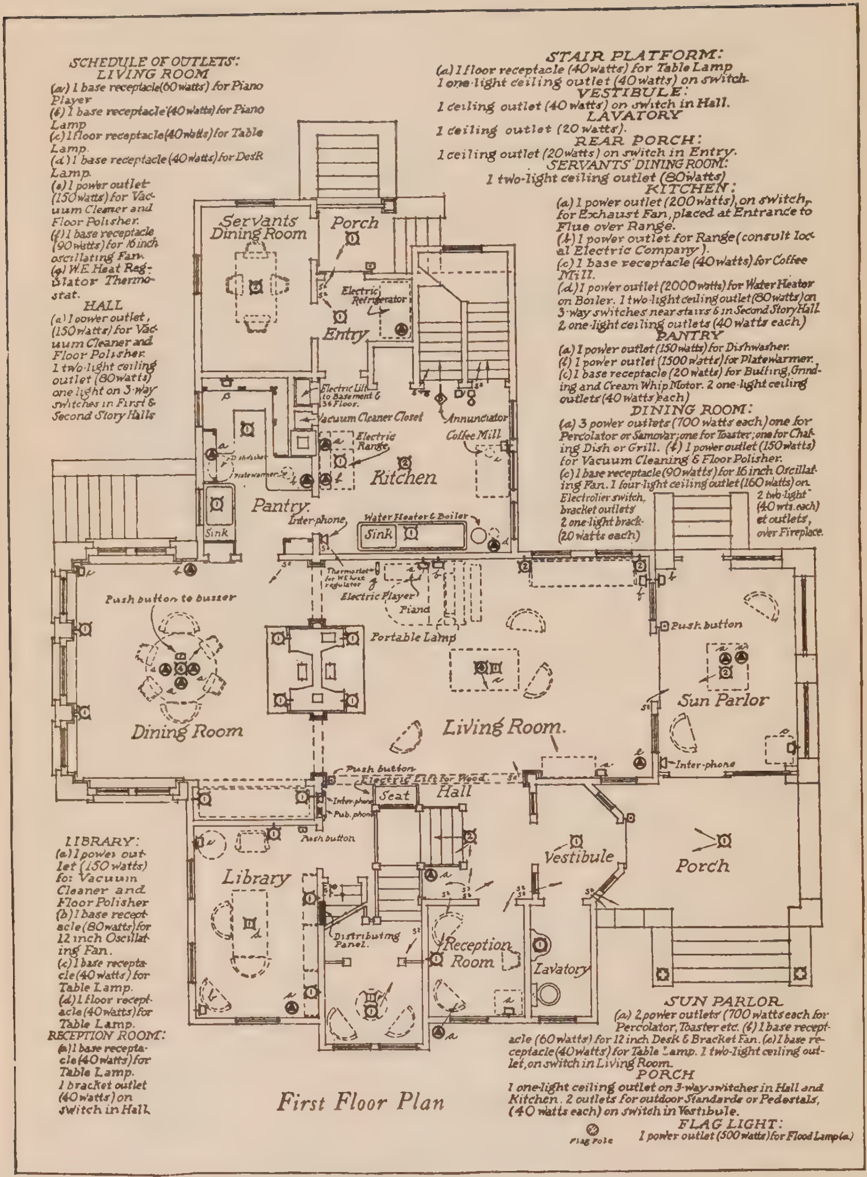
NOTE: Symbols for outlets are shown on Third Floor Plan

Basement Plan

NOTE: The purpose of these drawings is to suggest adequate electric wiring, location of outlets and satisfactory equipment for the Home Electrical. They are not intended to suggest a type of architecture.

Courtesy of the Habirshaw Electric Cable Co., Inc.

FIG. 70



SCHEDULE OF OUTLETS:
LIVING ROOM
(a) 1 base receptacle (60 watts) for Piano Player
(b) 1 base receptacle (40 watts) for Piano Lamp
(c) 1 floor receptacle (40 watts) for Table Lamp.
(d) 1 base receptacle (40 watts) for Desk Lamp.
(e) 1 power outlet (150 watts) for Vacuum Cleaner and Floor Polisher.
(f) 1 base receptacle (90 watts) for 16 inch oscillating Fan.
(g) W.E. Heat Regulator Thermostat.

HALL
(a) 1 power outlet, (150 watts) for Vacuum Cleaner and Floor Polisher.
1 two-light ceiling outlet (80 watts) one light on 3-way switches in First & Second Story Halls

STAIR PLATFORM:
(a) 1 floor receptacle (40 watts) for Table Lamp
1 one-light ceiling outlet (40 watts) on switch.

VESTIBULE:
1 ceiling outlet (40 watts) on switch in Hall.

LAVATORY
1 ceiling outlet (20 watts).

REAR PORCH:
1 ceiling outlet (20 watts) on switch in Entry.

SERVANTS' DINING ROOM:
1 two-light ceiling outlet (80 watts)

KITCHEN:
(a) 1 power outlet (200 watts), on switch, for Exhaust Fan, placed at Entrance to Flue over Range.
(b) 1 power outlet for Range (consult local Electric Company).
(c) 1 base receptacle (40 watts) for Coffee Mill.
(d) 1 power outlet (2000 watts) for Water Heater on Boiler. 1 two-light ceiling outlet (80 watts) on 3-way switches near stairs & in Second Story Hall. 2 one-light ceiling outlets (40 watts each)

PANTRY
(a) 1 power outlet (150 watts) for Dishwasher.
(b) 1 power outlet (1500 watts) for Platewarmer.
(c) 1 base receptacle (20 watts) for Buffing, Grinding and Cream Whip Motor. 2 one-light ceiling outlets (40 watts each)

DINING ROOM:
(a) 3 power outlets (700 watts each) one for Percolator or Samovar; one for Toaster; one for Chafing Dish or Grill. (b) 1 power outlet (150 watts) for Vacuum Cleaning & Floor Polisher.
(c) 1 base receptacle (90 watts) for 16 inch Oscillating Fan. 1 four-light ceiling outlet (160 watts) on Electrolier switch, 2 two-light (40 wts. each) bracket outlets over Fireplace. 2 one-light bracket outlets (20 watts each)

LIBRARY:
(a) 1 power outlet (150 watts) for Vacuum Cleaner and Floor Polisher
(b) 1 base receptacle (80 watts) for 12 inch Oscillating Fan.
(c) 1 base receptacle (40 watts) for Table Lamp.
(d) 1 floor receptacle (40 watts) for Table Lamp.

RECEPTION ROOM:
(a) 1 base receptacle (40 watts) for Table Lamp.
1 bracket outlet (40 watts) on switch in Hall.

SUN PARLOR
(a) 2 power outlets (700 watts each for Percolator, Toaster etc. (b) 1 base receptacle (60 watts) for 12 inch Desk & Bracket Fan. (c) 1 base receptacle (40 watts) for Table Lamp. 1 two-light ceiling outlet, on switch in Living Room.

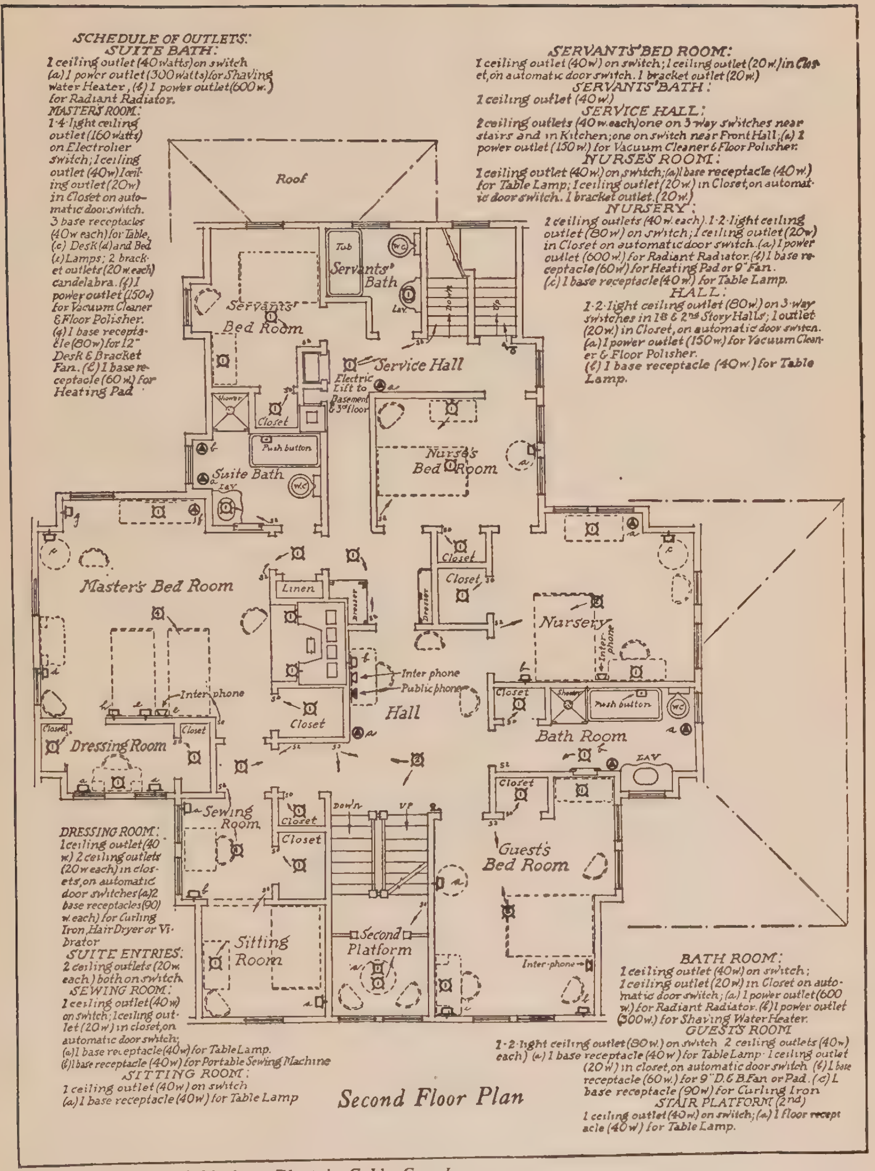
PORCH
1 one-light ceiling outlet on 3-way switches in Hall and Kitchen. 2 outlets for outdoor Standards or Pedestals, (40 watts each) on switch in Vestibule.

FLAG LIGHT:
1 power outlet (500 watts) for Flood Lamp (a)

First Floor Plan

Courtesy of the Habirshaw Electric Cable Co., Inc.

FIG. 71



SCHEDULE OF OUTLETS:

SUITE BATH:

1 ceiling outlet (40 watts) on switch (a) 1 power outlet (300 watts) for Shaving water Heater, (b) 1 power outlet (600 w.) for Radiant Radiator.

MASTERS ROOM:

1-4-light ceiling outlet (160 watts) on Electrolier switch; 1 ceiling outlet (40w) 1 ceiling outlet (20w) in Closet on automatic door switch. 3 base receptacles (40w each) for Table, (c) Desk (d) and Bed (e) Lamps; 2 bracket outlets (20 w. each) candelabra. (f) 1 power outlet (150w) for Vacuum Cleaner & Floor Polisher. (g) 1 base receptacle (80w) for 12" Desk & Bracket Fan. (l) 1 base receptacle (60 w.) for Heating Pad

SERVANTS' BED ROOM:

1 ceiling outlet (40w) on switch; 1 ceiling outlet (20 w.) in Closet, on automatic door switch. 1 bracket outlet (20 w.)

SERVANTS' BATH:

1 ceiling outlet (40 w.)

SERVICE HALL:

2 ceiling outlets (40 w. each) one on 3-way switches near stairs and in Kitchen; one on switch near Front Hall; (a) 1 power outlet (150 w.) for Vacuum Cleaner & Floor Polisher.

NURSES ROOM:

1 ceiling outlet (40 w.) on switch; (a) 1 base receptacle (40 w.) for Table Lamp; 1 ceiling outlet (20 w.) in Closet, on automatic door switch. 1 bracket outlet. (20 w.)

NURSERY:

2 ceiling outlets (40 w. each). 1-2-light ceiling outlet (80 w) on switch; 1 ceiling outlet (20w) in Closet on automatic door switch. (a) 1 power outlet (600 w.) for Radiant Radiator. (b) 1 base receptacle (60w) for Heating Pad or 9" Fan.
(c) 1 base receptacle (40 w.) for Table Lamp.

HALL:

1-2-light ceiling outlet (80w.) on 3-way switches in 1st & 2nd Story Halls; 1 outlet (20w.) in Closet, on automatic door switch.
(a) 1 power outlet (150 w.) for Vacuum Cleaner & Floor Polisher.
(b) 1 base receptacle (40w.) for Table Lamp.

DRESSING ROOM:

1 ceiling outlet (40 w.) 2 ceiling outlets (20 w each) in closets, on automatic door switches (a) 2 base receptacles (90 w. each) for Curling Iron, Hair Dryer or Vibrator

SUITE ENTRIES:

2 ceiling outlets (20 w. each) both on switch.

SEWING ROOM:

1 ceiling outlet (40 w) on switch; 1 ceiling outlet (20 w) in closet, on automatic door switch;
(a) 1 base receptacle (40w) for Table Lamp.
(b) 1 base receptacle (40w) for Portable Sewing Machine

SITTING ROOM:

1 ceiling outlet (40w.) on switch
(a) 1 base receptacle (40w) for Table Lamp

BATH ROOM:

1 ceiling outlet (40w.) on switch;
1 ceiling outlet (20 w.) in Closet on automatic door switch; (a) 1 power outlet (600 w.) for Radiant Radiator. (b) 1 power outlet (300w.) for Shaving Water Heater.

GUESTS ROOM

1-2-light ceiling outlet (80 w.) on switch 2 ceiling outlets (40w) each) (a) 1 base receptacle (40 w) for Table Lamp· 1 ceiling outlet (20 w) in closet, on automatic door switch (b) 1 base receptacle (60 w.) for 9" D.C B.Fan or Pad. (c) 1 base receptacle (90w) for Curling Iron

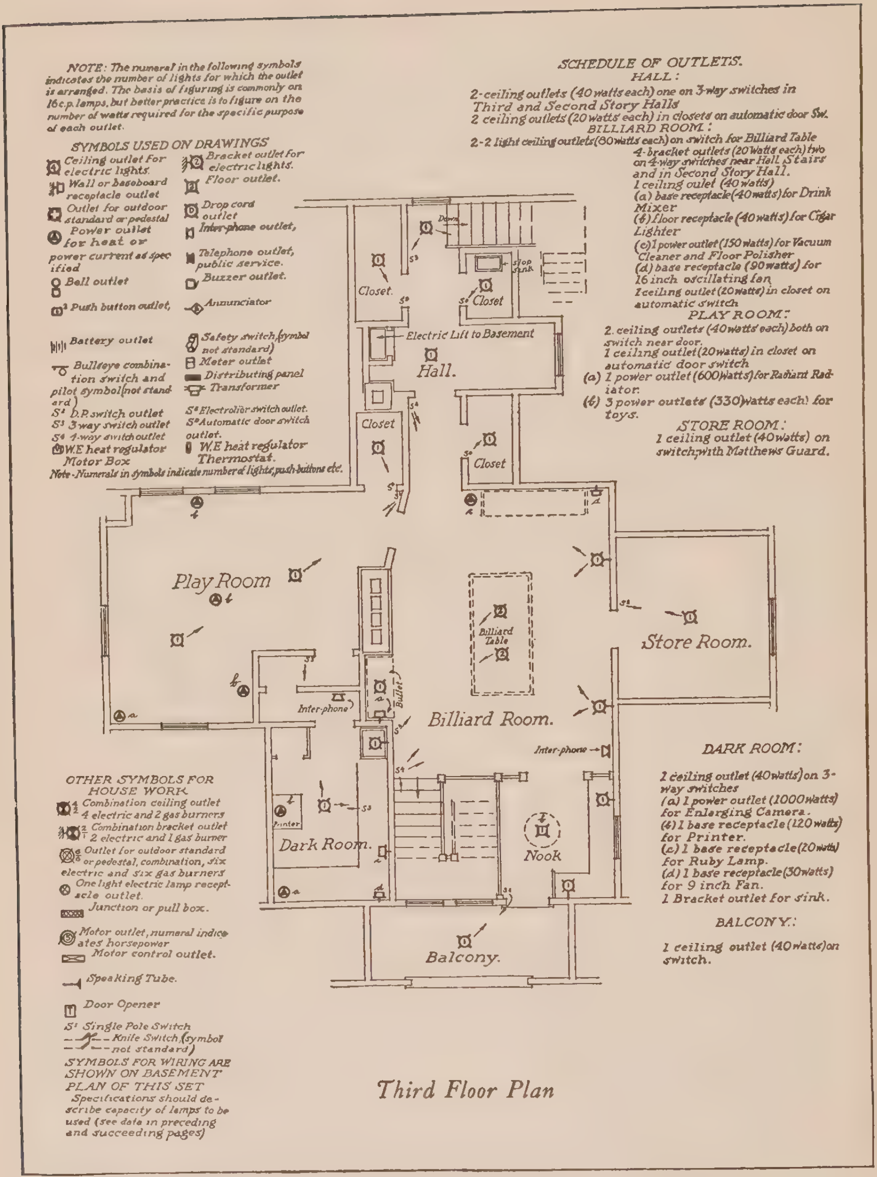
STAIR PLATFORM (2nd)

1 ceiling outlet (40 w.) on switch; (a) 1 floor receptacle (40 w) for Table Lamp.

Second Floor Plan

Courtesy of the Habirshaw Electric Cable Co., Inc.

FIG. 72



NOTE: The numeral in the following symbols indicates the number of lights for which the outlet is arranged. The basis of figuring is commonly on 16c.p. lamps, but better practice is to figure on the number of watts required for the specific purpose of each outlet.

SYMBOLS USED ON DRAWINGS

Ceiling outlet for electric lights.
Bracket outlet for electric lights.
Wall or baseboard receptacle outlet
Floor outlet.
Outlet for outdoor standard or pedestal
Drop cord outlet
Power outlet for heat or power current as specified
Inter-phone outlet,
Telephone outlet, public service.
Bell outlet
Buzzer outlet.
Push button outlet,
Annunciator
Battery outlet
Safety switch, (symbol not standard)
Bullseye combination switch and pilot symbol (not standard)
Meter outlet
Distributing panel
Transformer
S^2 D.P. switch outlet
S^3 3 way switch outlet
S^4 4-way switch outlet
S^E Electrolier switch outlet.
S^D Automatic door switch outlet.
W.E heat regulator Motor Box
W.E heat regulator Thermostat.
Note - Numerals in symbols indicate number of lights, push-buttons etc.

SCHEDULE OF OUTLETS.

HALL:

2-ceiling outlets (40 watts each) one on 3-way switches in Third and Second Story Halls
2 ceiling outlets (20 watts each) in closets on automatic door Sw.

BILLIARD ROOM:

2-2 light ceiling outlets (80 watts each) on switch for Billiard Table
4-bracket outlets (20 Watts each) two on 4-way switches near Hall Stairs and in Second Story Hall.
1 ceiling oulet (40 watts)
(a) base receptacle (40 watts) for Drink Mixer
(b) floor receptacle (40 watts) for Cigar Lighter
(c) 1 power outlet (150 watts) for Vacuum Cleaner and Floor Polisher
(d) base receptacle (90 watts) for 16 inch oscillating fan
1 ceiling outlet (20 watts) in closet on automatic switch

PLAY ROOM:

2. ceiling outlets (40 watts each) both on switch near door.
1 ceiling outlet (20 watts) in closet on automatic door switch
(a) 1 power outlet (600 watts) for Radiant Radiator.
(b) 3 power outlets (330 watts each) for toys.

STORE ROOM:

1 ceiling outlet (40 watts) on switch, with Matthews Guard.

DARK ROOM:

1 ceiling outlet (40 watts) on 3-way switches
(a) 1 power outlet (1000 watts) for Enlarging Camera.
(b) 1 base receptacle (120 watts) for Printer.
(c) 1 base receptacle (20 watts) for Ruby Lamp.
(d) 1 base receptacle (30 watts) for 9 inch Fan.
1 Bracket outlet for sink.

BALCONY:

1 ceiling outlet (40 watts) on switch.

OTHER SYMBOLS FOR HOUSE WORK

Combination ceiling outlet 4 electric and 2 gas burners
Combination bracket outlet 2 electric and 1 gas burner
Outlet for outdoor standard or pedestal, combination, six electric and six gas burners
One light electric lamp receptacle outlet.
Junction or pull box.
Motor outlet, numeral indicates horsepower
Motor control outlet.
Speaking Tube.
Door Opener
S^1 Single Pole Switch
Knife Switch, (symbol not standard)

SYMBOLS FOR WIRING ARE SHOWN ON BASEMENT PLAN OF THIS SET

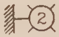
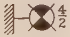
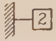
Specifications should describe capacity of lamps to be used (see data in preceding and succeeding pages)

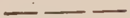
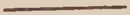
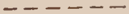
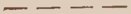
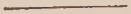
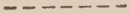
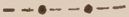
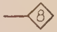
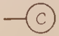
Third Floor Plan

Courtesy of the Habirshaw Electric Cable Co., Inc.

FIG. 73

ELECTRICAL INDICATIONS

	Ceiling outlet; electric only. Number of center indicates number of standard 50 watt electric lamps	Show as many symbols as there are switches, or in case of a very large group of switches indicate the number of switches by a Roman numeral, thus: S^1 XII means 12 single pole switches. Describe type of switch in specifications, that is flush or surface, push button or snap.
	Ceiling outlet; combination 4/2 indicates 200 watt electric light capacity and 2 gas burners	
	Bracket outlet; electric only. Numeral in center indicates number 50 watt electric lamps	
	Bracket outlet; combination 4/2 indicates 200 watt electric light capacity and 2 gas burners	
	Wall or baseboard receptacle outlet: Numeral in center indicates number of standard 50 watt electric lamps	
	Floor outlet: Numeral in center indicates number of 50 watt electric lamps	
	Outlet for outdoor standard or pedestal; electric only. Numeral indicates number of 50 watt electric lamps	
	Outlet for outdoor standard or pedestal: Combination 6/6 indicates 300 watt electric light capacity lamps, 6 gas burners	
	Special outlet for lighting, heating or power current as described in specifications	
	Drop cord outlet	
	One light outlet for lamp receptacle	

	Main or feeder run under floor concealed
	Main or feeder run concealed under floor above
	Main or feeder run exposed
	Branch circuit run concealed under floor
	Branch circuit run concealed under floor above
	Branch circuit run exposed
	Pole line
	Riser
	Telephone outlet; Private service
	Telephone outlet; Public service
	Bell outlet
	Buzzer outlet
	Push button outlet; Numeral indicates number of pushes
	Annunciator; Numeral indicates number of points
	Speaking tube
	Watchman clock outlet
	Watchman station outlet

S^1	Single Pole Switch outlet	Show as many symbols as there are switches, or in case of a very large group of switches indicates the number of switches by a Roman numeral thus: S^1 XII means 12 single pole switches. Describe type of switch in specifications, that is flush or surface, push button or snap
S^2	Double Pole Switch outlet	
S^3	3-way switch outlet.	
S_D	Automatic door switch outlet	
S_E	Electrolier switch outlet	
⊟	Meter outlet	
▬	Distribution panel	
▩	Junction or pull box	
⑤	Motor outlet: Numeral in center indicates horse power	
⊠	Motor control outlet	
⊣⊢	Transformer	
— - —	Circuit for clock, telephone, bell or other service run under floor concealed. Kind of service wanted ascertained by symbol to which line connects	
—··—	Circuit for clock, telephone, bell or other service run under floor above, concealed. Kind of service wanted ascertained by symbol to which line connects	

I L T 453—1839B

FIG. 74

⊠	Special outlet; signal system as described in specifications
‖‖	Battery outlet

NOTE: If other than standard 50 watt electric lamps capacity is desired specifications should describe capacity of lamp desired

SUGGESTIONS IN CONNECTION WITH STANDARD SYMBOLS FOR WIRING PLANS

It is important that ample space be allowed for the installation of mains, feeders, branches and distribution panels.

It is desirable that a key to the symbols used accompany all plans

If mains, feeders, branches and distribution panels are shown on the plans it is desirable that they be designated by letters or numbers.

Heights of center of wall outlets;
(unless otherwise specified)

Living rooms	5′-6″
Chambers	5′-0″
Corridors	6′-3″
Offices	6′-0″

Heights of Switches (unless otherwise specified) 4′-0″

Fig. 75, was recommended and adopted by the Association of Electragists, International; The American Institute of Architects; and the American Institute of Electrical Engineers; and approved by the American Engineering Standards Committee on March 6, 1924. These later symbols have not yet come into universal use. There is no doubt, however, but that they will be used more and more in the course of time, and will ultimately supersede those given in Fig. 74. This new system is therefore given so that, if the symbols are found on plans, they may be understood.

99. As stated in the note on Fig. 70, the drawings are intended to show diagrams of the various floor plans and the customary application of symbols to the rooms usually found in such a residence. A careful study of these plans in connection with the symbols given on the illustrations and in Fig. 74, will furnish an excellent idea of the complete fittings for a house. Symbols have not been standardized for some devices, such as the safety switch shown in Fig. 70. Architects and engineers who use special symbols not indicated in Fig. 74, or who may use other systems of symbols, generally show on one or more of the plans a list of the symbols used for the guidance of the wireman.

100. In Fig. 76 is shown a portion of a plan of a hotel building. In this plan all the outlets, as well as the wires supplying these outlets, are shown. Panel-boards from which these wires receive the current from the feeders are also shown. In the room *D* will be found indications of ceiling lights with two lights at *a*, wall brackets containing two lights at *b*, a base outlet for one light at *c*, and a floor outlet for two lights at *d*. At *e* are shown switches, one of which controls the two side outlets *b* and another switch controlling the ceiling outlet *a*. A secondary clock is shown at *f*, and a telephone outlet is shown at *g*. These indications are all shown in accordance with the list of symbols given in the upper right-hand corner of the figure. The indications are practically the same as in Fig. 74.

101. The wiring from the floor outlet *d*, Fig. 76, to the base outlet and through the point *h* and to the panel-board, is

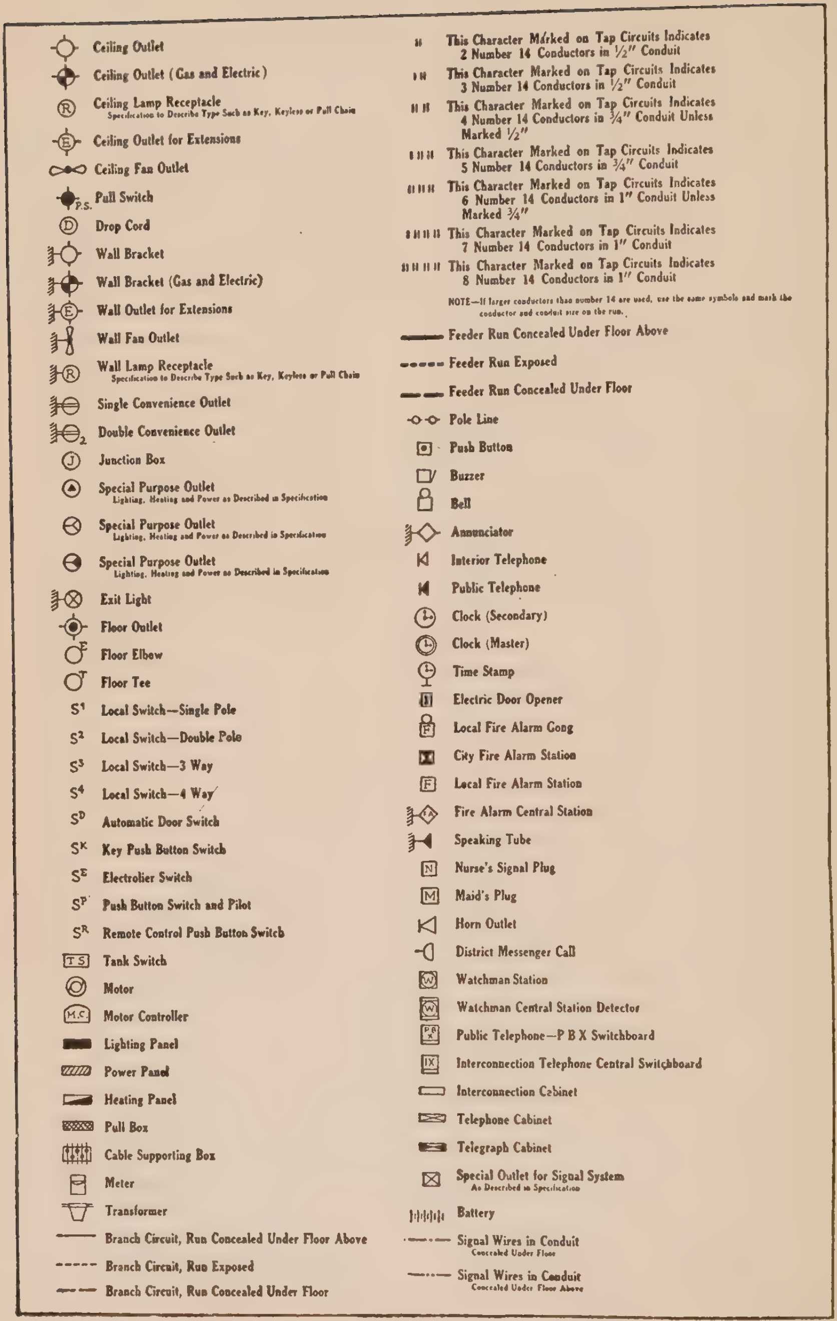
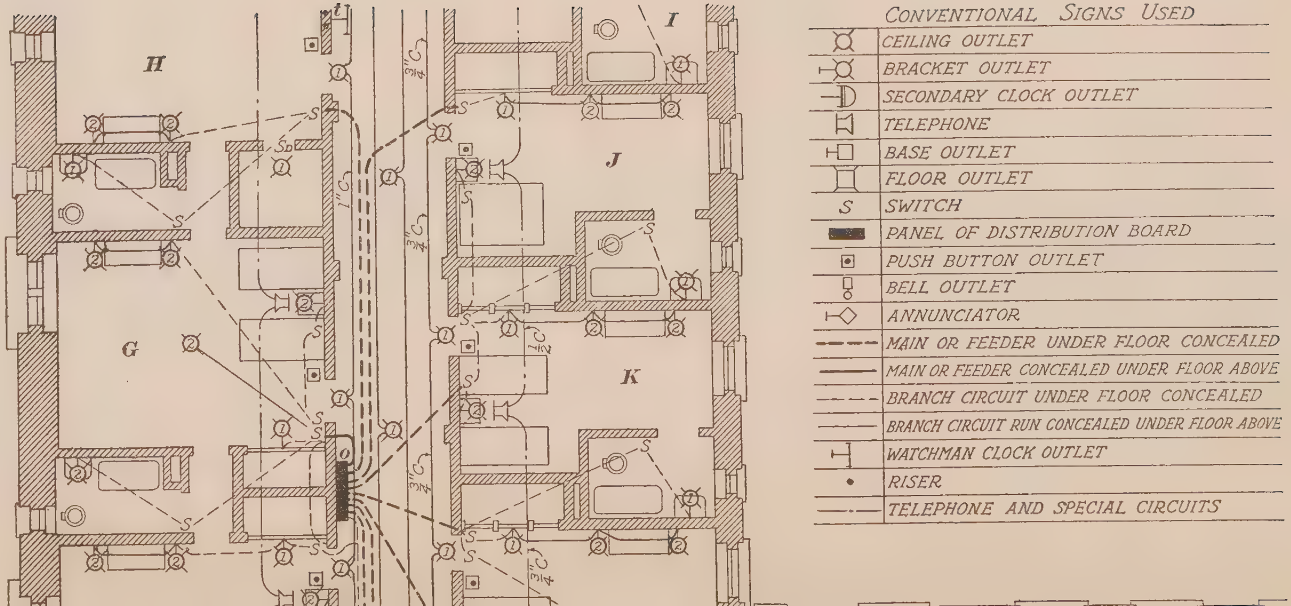

Ceiling Outlet
Ceiling Outlet (Gas and Electric)
Ceiling Lamp Receptacle
Specification to Describe Type Such as Key, Keyless or Pull Chain
Ceiling Outlet for Extensions
Ceiling Fan Outlet
P.S.
Pull Switch
Drop Cord
Wall Bracket
Wall Bracket (Gas and Electric)
Wall Outlet for Extensions
Wall Fan Outlet
Wall Lamp Receptacle
Specification to Describe Type Such as Key, Keyless or Pull Chain
Single Convenience Outlet
Double Convenience Outlet
Junction Box
Special Purpose Outlet
Lighting, Heating and Power as Described in Specification
Special Purpose Outlet
Lighting, Heating and Power as Described in Specification
Special Purpose Outlet
Lighting, Heating and Power as Described in Specification
Exit Light
Floor Outlet
Floor Elbow
Floor Tee
Local Switch—Single Pole
Local Switch—Double Pole
Local Switch—3 Way
Local Switch—4 Way
Automatic Door Switch
Key Push Button Switch
Electrolier Switch
Push Button Switch and Pilot
Remote Control Push Button Switch
Tank Switch
Motor
Motor Controller
Lighting Panel
Power Panel
Heating Panel
Pull Box
Cable Supporting Box
Meter
Transformer
Branch Circuit, Run Concealed Under Floor Above
Branch Circuit, Run Exposed
Branch Circuit, Run Concealed Under Floor
This Character Marked on Tap Circuits Indicates 2 Number 14 Conductors in ½″ Conduit
This Character Marked on Tap Circuits Indicates 3 Number 14 Conductors in ½″ Conduit
This Character Marked on Tap Circuits Indicates 4 Number 14 Conductors in ¾″ Conduit Unless Marked ½″
This Character Marked on Tap Circuits Indicates 5 Number 14 Conductors in ¾″ Conduit
This Character Marked on Tap Circuits Indicates 6 Number 14 Conductors in 1″ Conduit Unless Marked ¾″
This Character Marked on Tap Circuits Indicates 7 Number 14 Conductors in 1″ Conduit
This Character Marked on Tap Circuits Indicates 8 Number 14 Conductors in 1″ Conduit
NOTE—If larger conductors than number 14 are used, use the same symbols and mark the conductor and conduit size on the run.
Feeder Run Concealed Under Floor Above
Feeder Run Exposed
Feeder Run Concealed Under Floor
Pole Line
Push Button
Buzzer
Bell
Annunciator
Interior Telephone
Public Telephone
Clock (Secondary)
Clock (Master)
Time Stamp
Electric Door Opener
Local Fire Alarm Gong
City Fire Alarm Station
Local Fire Alarm Station
Fire Alarm Central Station
Speaking Tube
Nurse's Signal Plug
Maid's Plug
Horn Outlet
District Messenger Call
Watchman Station
Watchman Central Station Detector
Public Telephone—P B X Switchboard
Interconnection Telephone Central Switchboard
Interconnection Cabinet
Telephone Cabinet
Telegraph Cabinet
Special Outlet for Signal System
As Described in Specification
Battery
Signal Wires in Conduit
Concealed Under Floor
Signal Wires in Conduit
Concealed Under Floor Above

FIG. 75


CONVENTIONAL SIGNS USED
CEILING OUTLET
BRACKET OUTLET
SECONDARY CLOCK OUTLET
TELEPHONE
BASE OUTLET
FLOOR OUTLET
S SWITCH
PANEL OF DISTRIBUTION BOARD
PUSH BUTTON OUTLET
BELL OUTLET
ANNUNCIATOR
MAIN OR FEEDER UNDER FLOOR CONCEALED
MAIN OR FEEDER CONCEALED UNDER FLOOR ABOVE
BRANCH CIRCUIT UNDER FLOOR CONCEALED
BRANCH CIRCUIT RUN CONCEALED UNDER FLOOR ABOVE
WATCHMAN CLOCK OUTLET
RISER
TELEPHONE AND SPECIAL CIRCUITS
H
G
I
J
K
t
o
S
SD
1″C
3/4″C
1/2″C
1
2

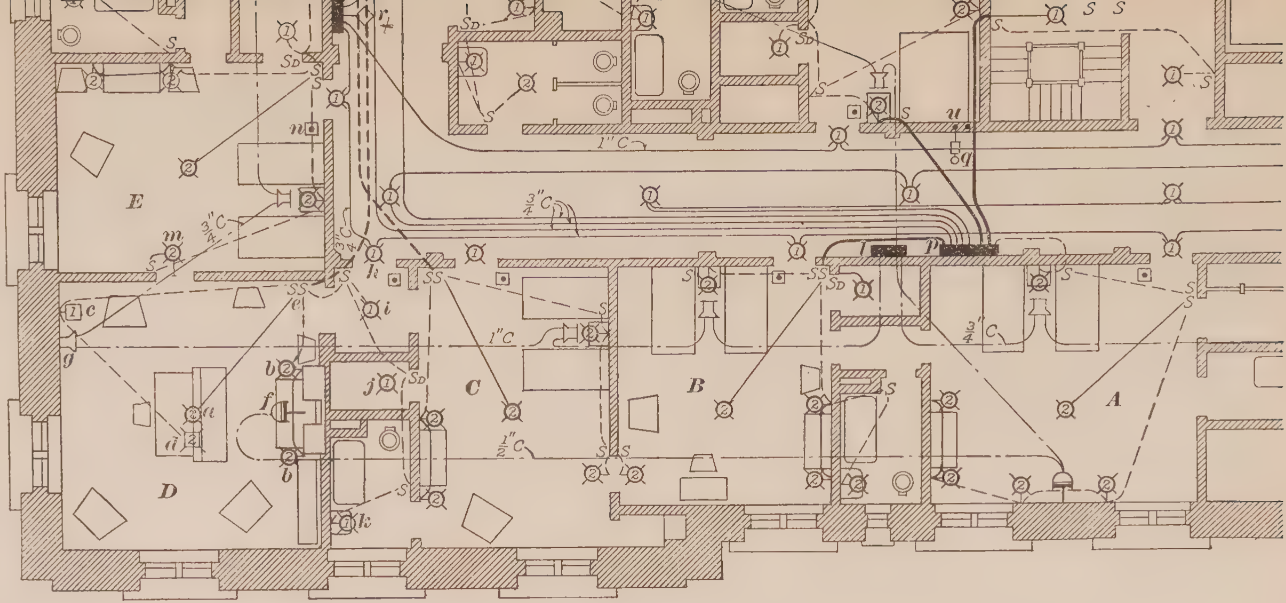


Fig. 76

shown by a broken line indicating a branch circuit line run concealed under the floor. The side lights *b* are wired across the face of the chimney at a convenient place above these outlets, as shown by the solid line. This conduit then drops beneath the floor below and is indicated by a broken line the same as for the base and floor outlets. A conduit from the ceiling outlet *a* is shown solid, indicating that it is concealed in the floor above. This conduit drops to the floor at *e* and connects with the wire leading to the panel-board. The light *i* in the vestibule is also connected with this wire through the switch as shown. Additional lights at *j* and *k* are placed on this circuit. The light *j* is a closet ceiling light, and is operated by the door switch S_D, the current continuing through a switch to the lights *k*. The wiring for these lights and switches is carried beneath the floor, as indicated by the broken line. The wires from the lights *j* and *k*, notwithstanding the fact that they are on the same circuit as the lights in the room *D*, are controlled from the room *C*. In counting the lights on this circuit, it will be noted that outlets for twelve lights have been provided. The wiring for the secondary clock is shown by a dot-and-dash line, which indicates a clock, bell, telephone, or other service. This clock *f* is on the same circuit as the clock in the room *A*, and is connected with the panel-board *l*.

102. The telephone is on another circuit, and is connected with the telephone outlets in the other rooms, as shown on the drawings. This circuit also leads to the box *l*, Fig. 76. The box *l* is the terminal for low-voltage circuits such as telephones, clocks, etc. Similar telephone circuits also lead from this box to the telephone in rooms *M*, *L*, *K*, etc. Room *D* has lights placed on each side of the mantel. The outlet *a* is dropped from the ceiling and should be over the center of the room. The floor outlet *d* is designed to supply a special lamp placed near the center of the room. The base outlet *c* is designed to supply current to a floor light or lamp. In the bedroom *E* will be placed a ceiling light with two outlets, controlled by a switch near the entrance to the room, and there are two side outlets *q*, one on each side of a bureau or dressing table. These lights are controlled by a switch at one side of the door, as shown. An outlet near the table between the beds provides for a lamp which may be placed on the table, controlled by a switch which can be reached from or controlled by a person lying in either bed.

103. An outlet *m*, Fig. 76, is placed where shown above the door between the rooms *D* and *E*. The object of this light is to enable persons to see themselves in a full-length mirror fitted in the door between these rooms. This light is controlled by a switch at one side of the door as shown.

104. Over the door between the rooms *B* and *C*, Fig. 76, two lights are shown. In this case a mirror is set in each side of the door. Over each door in the corridor is shown a ceiling-light outlet, the idea of the light being to locate the numbers on the doors easily, to furnish light by which a guest may see easily the number on the door, and to provide light in the room until the switch inside the door is located.

105. The panel-board *o*, Fig. 76, takes care of the circuits to the outlets for the rooms *D, E, F, G, J, K,* and *L*, and is placed centrally so that these circuits will be as short as possible to avoid unnecessary loss in voltage at the terminals of these circuits. Another panel-board, which takes care of the rooms in its vicinity, is shown at *p*. Additional ceiling lights are shown in the middle of the corridor, on two circuits, so that each alternate light or the entire series may be turned on, as desired. At *q* a bell is indicated which may be used for an alarm in case of fire. At *r* is an annunciator.

106. In the elevators are indications of drop lights in each car, which are connected with a flexible cord that moves up and down as the elevator rises or descends. An annunciator is shown in each elevator, which responds to the push button *s*, Fig. 76. At *t* is shown a watchman's clock, which is rung periodically at night by the watchman. At *u* two risers extend up through the building to feed the bell and other devices.

107. The sizes of some of the conduits are marked on the plan as shown. Thus, $\frac{3}{4}''c.$ indicates a $\frac{3}{4}$-inch conduit. The symbols used in this plan are repeated in the upper right-hand corner of the illustration.

108. The lights in the elevators are on a circuit with the lights in the halls at the elevator. The lights in the elevators are taken off the circuit near the central floor of the building, half way in the height of the building. The circuit supplying the hall lights will, of course, occur on every floor.

109. A careful study of this plan, together with the table of symbols shown in Fig. 74, will give an excellent idea of the wiring of a large building. In a building of this kind care must be taken, first, to make the circuits as short as possible, so as to economize wire; and, secondly, to see that the number of lights on each circuit does not exceed the limit permitted by the Code.

HINTS ON WIRING

JOINTING

110. Jointing Conductors.—Whenever possible, joints in wires and cables should be avoided; but when unavoidable they should be made with the greatest care, for more fires are caused by defective electric connections than by inferior materials. In removing the insulation from wires preparatory to making a joint and in scraping the wire to clean it, great care should be taken not to nick the wires, thereby reducing both the carrying capacity and the mechanical strength. The cleaning should be thorough, preferably using sandpaper, in order to insure good electric connection and to permit the proper adhesion of the solder. Plain wire joints are shown in Figs. 77 to 79; joints of stranded conductors in Figs. 80 and 81.

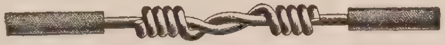


FIG. 77

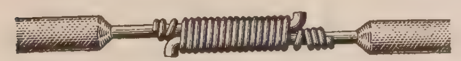


FIG. 78

Salts or acids should not be used for fluxes for soldering electric joints, because of their corrosive effect on copper and insulation. Pure resin or powdered resin mixed into a paste with pure ethyl alcohol makes a harmless and efficient flux. The following formula for soldering fluid is also useful:

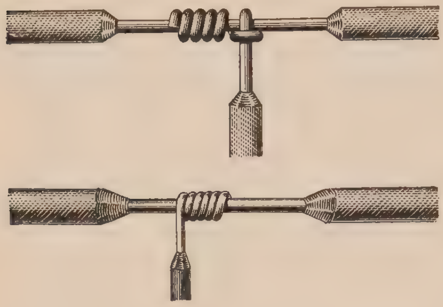


FIG. 79

Saturated solution of zinc chloride.	5 parts
Alcohol	4 parts
Glycerine	1 part

111. Insulation of Joints.—After soldering, the joint must be covered with insulation equivalent to that on the rest of the conductor. When joints in rubber-covered wires are to be insulated, two kinds of tape must be used; the first of pure rubber, and the second, called *friction tape*, of cloth saturated with moisture-proof adhesive material. The rubber tape can be obtained specially prepared by treatment with a chemical that renders the tape soft and adhesive on one side, or layers of pure rubber tape can be cemented together by rubber solution (cement) while the joint is being wrapped. The tape should be wound on spirally, stretching it all the time to make the completed joint as firm as possible. Rubber cement, if used, should be allowed

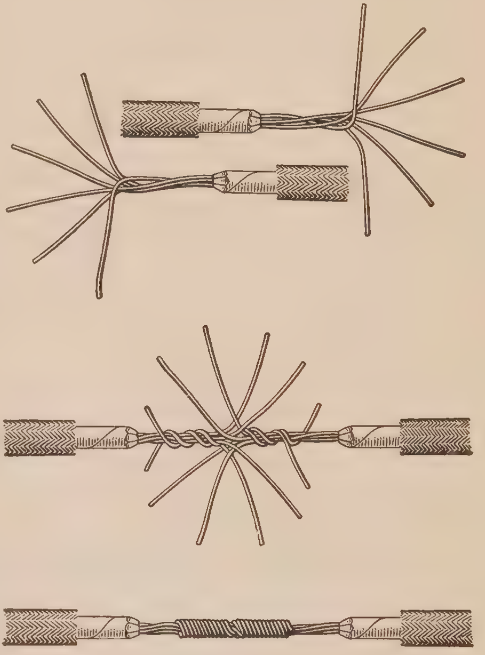


FIG. 80

to become almost dry before the next layer of tape is applied. The outer braided covering of the wire must be removed for a distance of at least 1 inch each way from the bare copper before the rubber tape is applied, because the rubber cement will not adhere to the braid. When the rubber tape has been wrapped on to a thickness a little greater than the insulation on the rest of the conductor, one or two layers of friction tape are applied, chiefly to give mechanical strength. Joints insulated by this method will be satisfactory under ordinary service conditions.

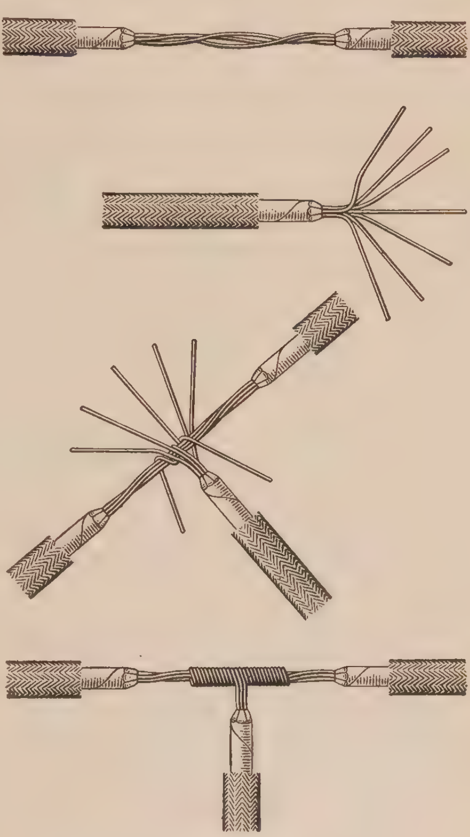


FIG. 81

112. In some cases specifications for interior wiring require that every joint shall be vulcanized. This process consists in converting, or curing the layers of strip insulation on the joint into a homogeneous coating that is continuous with the rubber covering of the manufactured cable. A joint to be vulcanized is first covered with a single layer of pure rubber tape and then with one or more layers of a special vulcanizing tape composed of rubber compounded with sulphur and French chalk, and covered finally with a well-chalked layer of cotton tape. The completed joint is placed in a mold, preferably immersed in a bath of molten sulphur, and kept at a temperature of about 300° F. for a half hour or so. When the vulcanization is complete, a wrapping of friction tape is applied.

CONCEALED WORK IN COMPLETED BUILDINGS

113. Preliminary Examination.—Most buildings of the non-fireproof type can be wired after completion by installing the conductors in flexible fabric conduit in the partitions and under the floors. Before beginning such a job the electrician should carefully determine the location of outlets as given by his specifications and then go over the house and study its layout, in order to determine the most convenient places to run the circuits. A single distribution box is usually located in the basement or attic near the entrance of the service wires, and from there the circuit work begins.

114. Fishing.—The wires, encased in the flexible tubing, are installed by the method commonly known as fishing. In order to run a line from basement to attic, for instance, the electrician takes up a single floor board at the side of the attic and lowers a thin steel tape, called a snake. When a clear drop to the basement has been found by exploring with the tape, the end is lowered to the basement, where the helper is ready to attach the wires, already placed in the flexible tubing. The electrician then withdraws the snake, bringing the wires with it. The operation of fishing is shown in Figs. 82 and 83; in the latter, the wires are being fished between wall outlets on adjacent floors.

Sometimes in fishing between floors through partitions cross-pieces between studs are encountered. In such cases the cross-pieces can be bored by an ordinary wood bit fastened in the end of a gas pipe in the other end of which is secured a brace. If the drop for the wires is behind a door casing, it may be possible to remove the casing and fish the wires around the cross-pieces.

Wires for ceiling outlets are fished under the floors. When floor boards can be removed and the wires run parallel to the joists, this is a simple matter, requiring only the removal of a board near the partition and of one over the outlet, as shown

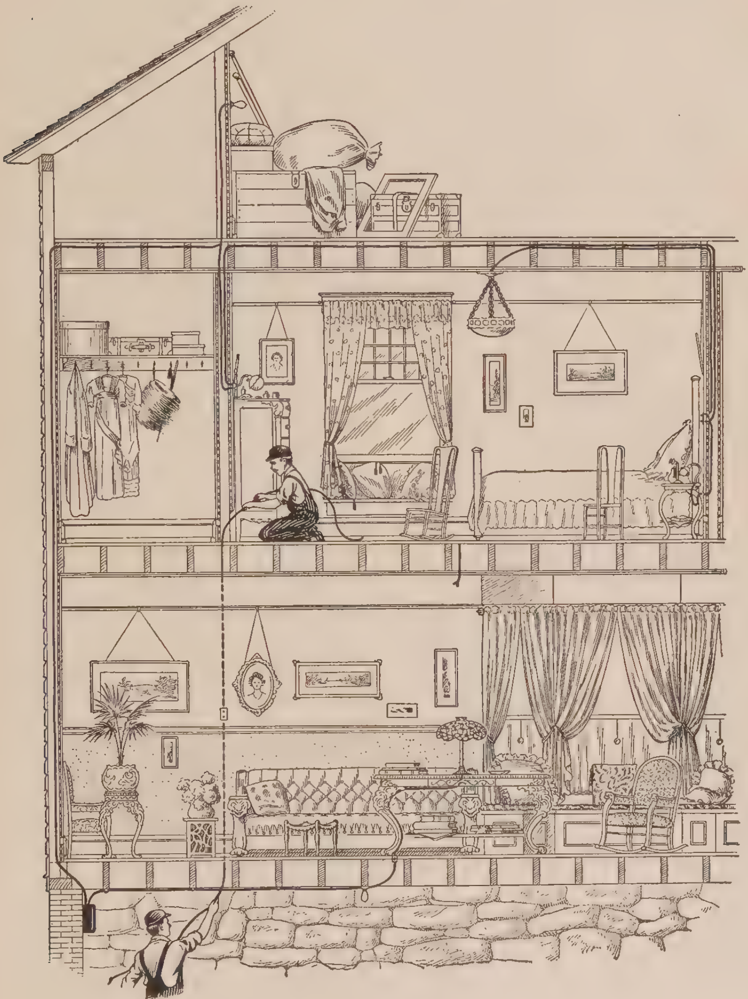


FIG. 82

in Fig. 84. When the floor boards of a room cannot be disturbed, it may be possible to run the snake from a closet, from which the removal of a board is usually permissible, directly

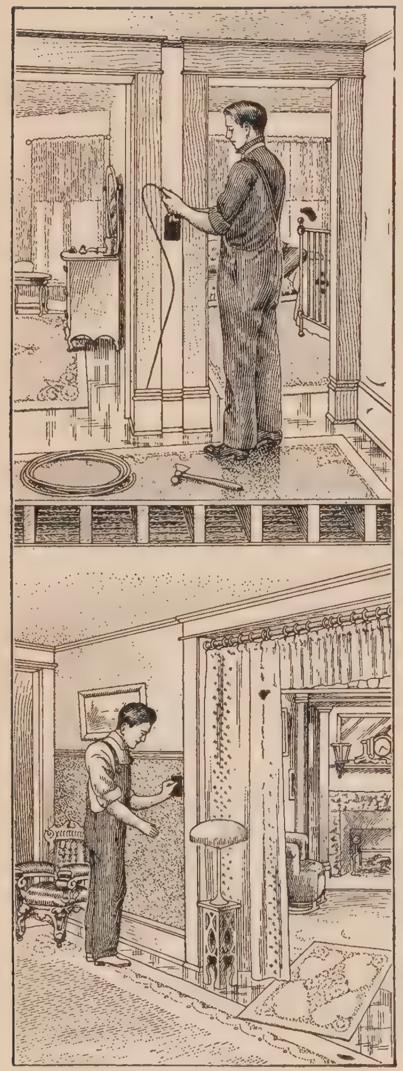


FIG. 83

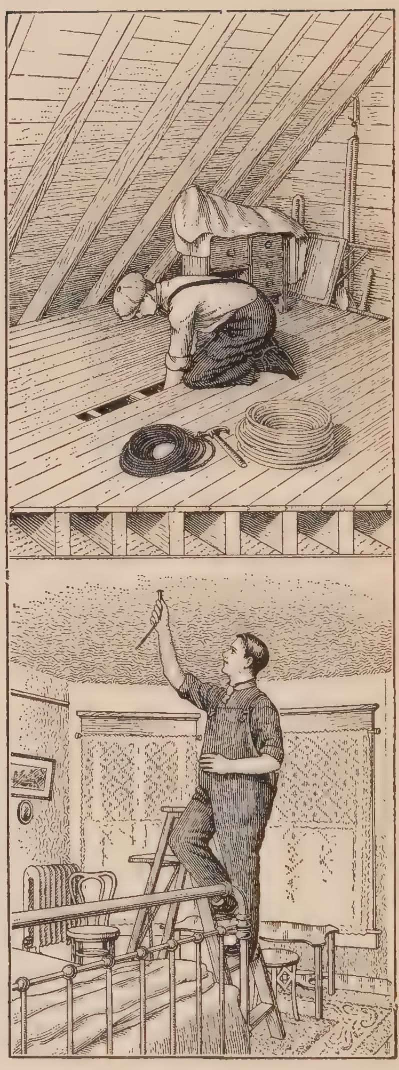


FIG. 84

to the opening in the ceiling; but where the joists run crosswise to the direction in which the wires are to be fished, a portion of the baseboard must be removed and the wires carried by this route to a point on the floor where they can be run parallel to the beams.

Armored cable, which, though more expensive than wires in flexible tubing, is superior in all other respects for this work, is fished from point to point in the manner just described.

115. Fastening Ceiling Fixtures.—When the floor above a ceiling outlet cannot be removed no opportunity is offered for nailing between the joists any support for the fixture stud. If the fixture is a light one, the fixture stud can be screwed directly to the lath, using a stud with as large as possible a spread between the feet. It is good practice, even with a light fixture, to reinforce the lath at the opening by a wooden block about half inch thick and small enough in diameter to go inside the fixture canopy. The weight of a heavier fixture can be distributed over a number of lath by slipping through the hole in the ceiling an iron strap tapped in the middle for a gas nipple. The strap can be pushed in endwise and pulled back across the hole by a string previously tied to it at the middle. When the nipple has been screwed into place a block of wood small enough to go inside the canopy is slipped over it and secured by a locknut, thus clamping the strap in position. The fixture can be fastened directly to the nipple. Care should be taken that the strap lies across the lath and not parallel to it.

INSTALLATION OF CONCEALED-CONDUIT WORK

116. System of Procedure.—Before starting to install a new conduit system in a building, the foreman electrician measures the available spaces of the riser shafts for the vertical sections of feeders and mains. He then ascertains the overall space conditions available for placing panel-boards and has the boards laid out by the manufacturer, so that the exact size of the outside panel cabinet may be determined. The foreman also counts up from the plans the number and various sizes of conduit dropping from the bottom of each cabinet to the floor or rising from the top of the cabinet to the ceiling or floor above, and furnishes the cabinet manufacturer with a templet showing the number and various sizes of holes required in each part of each cabinet. Previous to the receipt of the cabinets, or possibly after they are received, the electrician makes the measurements for the location of the various outlets to which conduit connections are to be made. The measurements are, of course, based on information obtained from the architect or owner of the building. After the rough cabinets have been received at the building, and after the definite location of each has been determined, each is set in place and the various runs of conduit from cabinets to outlets are made. In case it is too early to proceed with the branch circuit work on the floors, the condition of the building may be such that the system of vertical feeder and main conduits can be installed. When the conduit system is complete, the wires can be drawn in and the panel-boards and fixtures mounted and connected up.

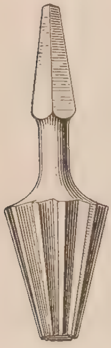


FIG. 85

117. Installing Conduit.—Before any conduit is installed, each piece should be examined thoroughly to be sure that there are no obstructions or rough places. An obstruction may prevent the drawing through of the wires or cables; and, even if the wires can be drawn through, the insulation may be so badly damaged by rough spots in the conduit that a break-down will soon occur. Equal care should be taken to remove all burrs or sharp edges from the ends of conduits, especially after a piece has been cut and before it has been threaded. The removal of burrs from the inside edge of a piece of conduit is quickly accomplished by the use of a reamer, Fig. 85, held in an ordinary brace. Before a piece of conduit is threaded the end should be smoothed off with a file. Before two pieces of conduit are coupled together, the threads should be painted with white lead to make the joint water-tight. The paint also protects the iron from corrosion.

Bends in rigid conduit should not be too short and care should be taken that the conduit is not flattened out at the bend. The correct types of bending tools or machines, three kinds of which are shown in Fig. 86, should be employed in making bends. Conduits should never be bent over a sharp edge.

Conduit ends should never be left open for any length of time where they are likely to become stopped with refuse or where water may enter them. The ends should always be kept closed by wooden plugs, or gas caps until the wires are to be installed.

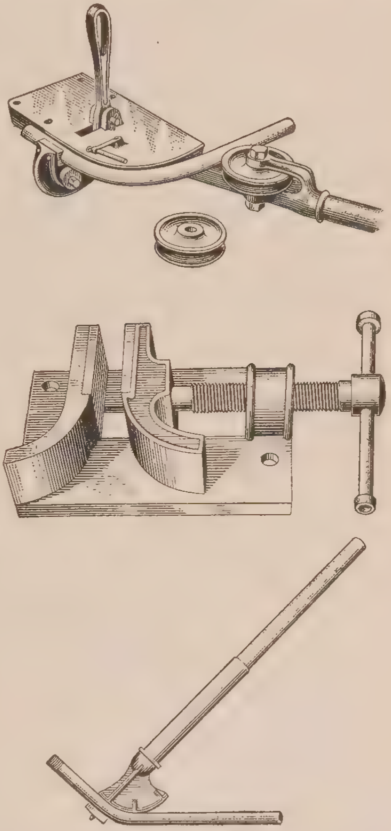


Fig. 86

118. The average conduit job will require the following tools, in addition to those already mentioned: Bench vises to hold the conduits while they are being cut and threaded; hack saws and pipe cutters for cutting conduits and nipples; stock and dies for threading; and an assortment of pipe wrenches. Special hand- and motor-driven machines are used for cutting and threading conduit on large installations where a large amount of such work is to be done.

119. Installing Wires in Conduit.—Wires should never be pulled into concealed conduit until the system is complete, floors laid, and walls and ceilings plastered. To facilitate the insertion of the wires, it is good practice to blow powdered soapstone into a conduit, especially if the run is very long and has many bends or offsets. A steel snake is used as a pathfinder for the wires. In the case of most branch circuit work the wires are drawn into the conduit by attaching them directly to the tape; but where a strong pull is required to draw in a wire or cable of considerable size, a hemp rope or a steel cable is drawn into the conduit by the tape, and the wires are drawn in by means of the rope. Large lead-encased cables, such as generator leads, require the use of a block and tackle, a strong enough pull being impossible by hand. Wires are drawn into conduits from reels mounted on improvised axles of conduit, crowbars, or anything else that will allow the reels to rotate easily as the wires pass through the conduits.

Few tools other than screwdrivers and wire pliers are required for the installation of wires in conduits. Hack saws are used to cut wires and cables too large to be cut by pliers or bolt cutters. Soldering torches, blow torches, and soldering irons are necessary for jointing and for sweating wire or cable ends into terminal lugs at switchboards, panels, etc.

TESTS

120. Kinds of Tests.—Tests on completed wiring are made to discover grounds, crosses, and wrong connections. Two tests are usually made: one before installing the fixtures and one after. Often fixtures are tested independently before they are put in place. All such tests are essentially tests of insulation resistance.

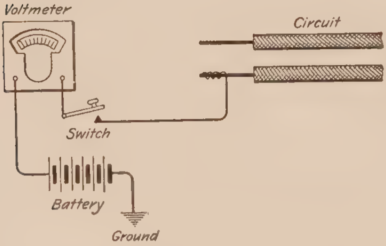


FIG. 87

121. Voltmeter Method. The voltmeter test is the most reliable of the various methods of testing the insulation resistance of electric wiring. A voltmeter capable of indicating from zero to 150 volts and a source of electromotive force—a battery of dry cells will serve—are required. The resistance of the voltmeter must be known, but the resistance of the battery, if a battery is used, can be neglected.

The voltage E of the battery is first measured by connecting the voltmeter directly across the battery terminals. The voltmeter is then connected in series with the insulation resistance as in Figs. 87 and 88, and the reading E_1 noted. If R_1 is the resistance of the voltmeter, the insulation resistance is

$$R = \frac{R_1 \ (E - E_1)}{E_1}$$

EXAMPLE.—The insulation resistance between the conductors of a circuit was measured by means of a voltmeter having a resistance of 20,000 ohms and a battery with an open-circuit electromotive force, as measured by the voltmeter, of 40 volts. With the insulation resistance in series with the voltmeter, as in Fig. 88, the reading was 5 volts. What was the insulation resistance?

SOLUTION.—The values to be substituted in the formula are $R_1 = 20{,}000$, $E = 40$, $E_1 = 5$. The insulation resistance was

$$R = \frac{20{,}000 \times (40 - 5)}{5} = \frac{20{,}000 \times 35}{5} = 140{,}000 \text{ ohms. Ans.}$$

122. Magneto Method.—A **magneto** is a small, hand-operated, alternating-current generator with permanent field magnets. For testing purposes, magnetos are mounted in a portable case, or box, with a bell. When making a test, the terminals of the instrument are connected to the circuit to be tested; if the bell can be rung, the circuit is faulty. Magnetos are designed to ring the bell through resistances of 5,000 to 10,000 ohms, or more. A magneto set cannot be used to measure insulation resistance; it is useful only in indicating the existence of a fault. As a rule, magnetos are not to be recommended for testing; because, if a circuit under test has sufficient capacity, a ring will be obtained, even though the insulation is without fault. Cable circuits are especially likely to possess capacity, and magneto tests on them are therefore

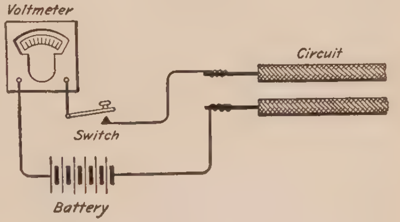


FIG. 88

unreliable. The magneto is, however, useful for testing branch circuits and fixtures.

123. Miscellaneous Methods.—The Wheatstone bridge, ohmmeter, and the megger can also be used for measuring insulation resistances. The first has the disadvantages of requiring a man experienced in its use and of requiring, in some cases, too long a time for a test. The ohmmeter is easily manipulated, and is direct-reading, but its range is too small for most insulation tests. The megger has none of these disadvantages and requires no external source of electromotive force, being superior in the last respect to the voltmeter.

124. Method of Procedure in Testing.—In testing an interior wiring installation with the fixtures in place, the method of procedure is to remove all lamps and disconnect all other apparatus, but to close all switches and have the circuits otherwise properly connected and fuses inserted. A bunch test of all feeders, mains, and branch circuits is then made at the bus-bars of the main switchboard. A test should first be made between each pair of the conductors themselves, after which a ground test should be made between each conductor and the ground. If leakage or a short circuit is indicated by the test at the bus-bars, the fault must be located by a process of elimination. To accomplish this, the feeders are cut out of circuit one at a time by opening the feeder switches or removing the fuses. When, upon opening a certain circuit, the indication of trouble disappears, the fault is known to be somewhere on that circuit. By following this feeder and its mains to the various centers of distribution the panel-board to which the defective branch is connected can be found, and the trouble on the branch can be located by inspection. Most short circuits and grounds will be found at the outlets, where the wiring connects with the fixtures; but, sometimes metallic veins in slate panel-boards cause leakage between the bus-bars; such panel-boards must be replaced.

The insulation resistance of an installation should be inversely proportional to the amount of wiring. The Code rules specify the value of insulation resistance that must be maintained.

LOCATION AND CALCULATION OF FEEDERS AND MAINS

LOCATION OF FEEDERS AND MAINS

125. Influences Determining Location of Feeders and Mains.—The location of feeders and mains in wiring installations is one of the first matters to be determined; their exact location must be fixed with reference to the design of the building and the location of water pipes, steam pipes, ventilating ducts, elevator shafts, etc. It is preferable, if possible, to obtain continuous vertical rising shafts for the feeders and mains so as to avoid horizontal runs under the floors, which must be made thicker than otherwise necessary if large conduits are to be accommodated. A center of distribution (panel) should be located at each rising point, because at these points the branch circuits originate. In a building of considerable floor area, where several rising points and several centers of distribution on each floor are necessary, the panels should be so located that the branch circuits do not exceed 100 feet in length, if possible.

126. Number of Feeders.—The number of feeders will be determined largely by the size of the building and, to a certain extent, by the desirable control of the lamps. For example, in many cases, particularly in office buildings, it is desirable to have separate feeders for the lamps in the halls, thereby making it possible to control hall lamps from the main switchboard. Separate feeders should be run for motors also, because motors, especially if started and stopped frequently or if operated on variable loads, interfere with the voltage regulation on the lighting feeders to such an extent that the lights fluctuate to a marked degree. Heating circuits that handle any considerable load should also be supplied by separate feeders.

Special feeders for exterior or decorative lighting should also be separate and controlled by switches installed on the main switchboard for the building.

The number of feeders depends also on the loads to be carried, because there is a limit to the size of conductor that it is economical or convenient to use. In general, it is not advisable to use conductors of over 1,000,000 circular mils area for feeders or mains, and if a greater area is required to avoid an excessive drop in voltage, the load should be divided among several feeders.

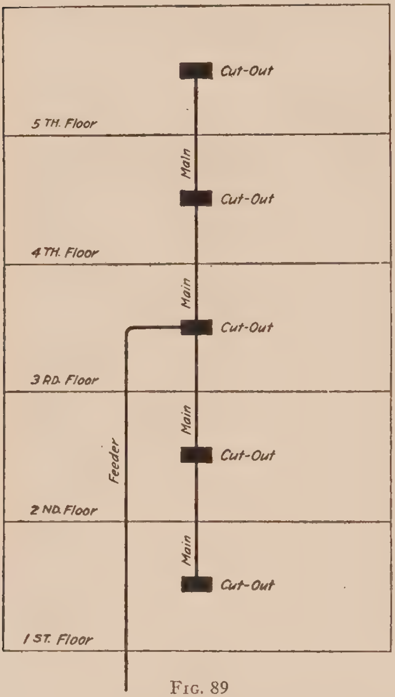


FIG. 89

127. Simple Feeder Layouts.—Though it is sometimes desirable to control the centers of distribution on one floor by a separate switch at the main switchboard, such a system should be avoided, if possible, because a separate feeder for each floor is required and horizontal mains from one panel to another are necessary. The most economical method is to supply several centers of distribution located on the same riser from one feeder as in Figs. 89 or 90. In cheap loft buildings, the method of Fig. 90 is often used to supply as many as seven or eight floors; but this method for so many floors is quite objectionable, as too many circuits depend on a fuse protecting a single feeder and in case of a short circuit the area affected by the disturbance is considerable. Furthermore, the voltage at the top floor must necessarily be considerably less than at the bottom floor.

It is usually advisable to run all of the conductors constituting a given feeder in one conduit. This is absolutely essential if alternating current is to be used, and is usually wise even if direct current is to be used, because a future change to alternating current can thus be anticipated.

In arranging the feeders and mains, it is good practice to make a preliminary layout, taking into consideration the space available for the risers, the number of centers of distribution that it is possible to obtain, and the estimated loads to be supplied by the feeders. A preliminary diagram should then be made showing the centers of distribution, the load in amperes supplied by each center, and the calculated lengths of the feeders and mains. The next step is to determine the sizes of the feeders and mains, assuming allowable losses.

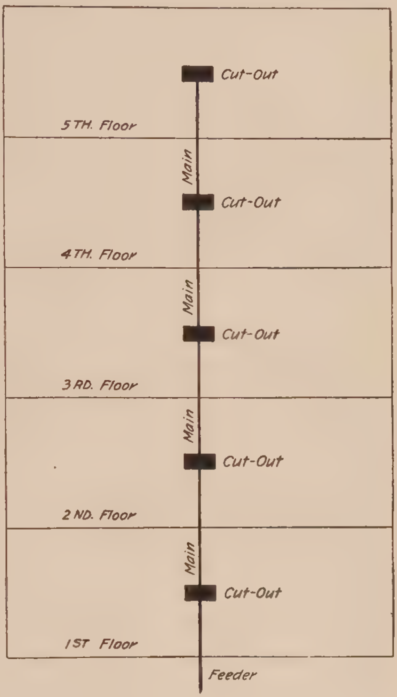


FIG. 90

CALCULATIONS FOR FEEDERS AND MAINS

PRELIMINARY CONSIDERATIONS

128. Factors Governing Calculations for Interior Wiring. The size of a conductor for a given purpose in an interior wiring installation is determined by two factors, the allowable voltage drop in the conductor and the carrying capacity of the wire or cable.

On the basis of commercial economy alone, the proper conductor to use for a given purpose is one in which the cost of energy lost as heat in the conductor in a given time is equal to the interest on the cost of the conductor itself for the same time. Electric considerations are, however, usually those that must be taken into account in determining the maximum voltage drop allowable; the life and brilliancy of incandescent lamps and the speed and output of electric motors all vary with the voltage impressed at the terminals of the apparatus. The allowable voltage drop is then the difference between the voltage at the main switchboard and the voltage required at the terminals of apparatus.

A conductor may be of sufficient size to carry its load without exceeding the allowable voltage drop and yet have current-carrying capacity below that specified by the National Electric Code. Carrying capacity then becomes the factor controlling the size of the conductor. In general, the size of a long conductor will be determined by voltage drop and of a short conductor by the carrying capacity. Except in the case of flexible cord used for wiring fixtures and in the case of low-potential work, no conductor smaller than No. 14 B. & S. is permitted by the code, even though the requirements as to voltage drop and carrying capacity are met by a smaller conductor.

129. Method of Proceeding With Calculations.—Before the size of a conductor for a given voltage drop can be calculated, the load to be carried by the conductor must be known. All of the lamps of a large installation are seldom used simultaneously, and in calculating voltage drop it is usually safe to assume a load less than that required by all of the lamps in the area supplied by a given feeder or main. The percentage of load to be assumed varies with the type of building and with the number of lamps supplied by one feeder; the greater the area supplied, the less likely that the entire load will be in use at one time. The calculations for a branch circuit should be made for the maximum possible load on that circuit, because the small number of lamps supplied may frequently be used simultaneously; but in most instances, all of several hundred lamps supplied by a feeder will rarely burn at the same time. Though no fixed rule can be given, 80 per cent. of the maximum possible load can usually be safely assumed when calculating the drops in feeders for hotels or office buildings. For the feeders supplying the lower floors of hotels, however, particularly those supplying the restaurant, lobby, ball room, etc., the maximum possible load should be used in calculations. In a factory building also, where all of the lamps may be used simultaneously, the greatest possible load should be used.

When carrying capacity is the basis on which the size of a conductor is to be determined, the maximum possible load must be taken into consideration. It is not safe to assume that no contingency will ever arise to require the simultaneous burning of all lamps on a feeder; when such a contingency does arise, the feeder must be able to carry the load without overheating.

130. Having determined the load to be transmitted by the various conductors, the next step in the calculations is to assume a certain voltage loss to be allowed in the various feeders, mains, and branches comprising a circuit between the main switchboard and the consuming devices. The amount of this loss will vary with the size of the building and with the lengths of the circuits, and should be kept as small as possible without going to the extreme of using unnecessarily large conductors. In ordinary practice, the drop from the point of service supply to lamps will vary from 3 to 4 per cent. It is usual to allow approximately 1 to $1\frac{1}{2}$ per cent. of this drop in the branch circuits and the balance in the feeders and mains. In conductors supplying motors, the total drop can be increased to 5 or 6 per cent., because motors usually do not require as close voltage regulation as lamps.

After the percentage of drop has been determined, the next step is to estimate the lengths of the various feeders and mains. A rough diagram of the feeder system should then be made, showing the feeders and mains from their points of origin to the cut-out panels, indicating on the diagram the loads at the various panels and the estimated lengths of the conductors. This being done, the numerical work of the calculations can be taken up.

DIRECT-CURRENT CALCULATIONS

131. Two-Wire Circuits.—The voltage drop in a conductor of resistance R ohms carrying a direct current of I amperes is $u=R\,I$. The resistance R of a copper conductor l_1 feet long and a circular mils in cross-sectional area is $\frac{10.8 l_1}{a}$; therefore, if the allowable drop in a pair of feeder or main conductors each l feet long and carrying I amperes is u volts, each of the conductors must have a cross-sectional area of

$$a=\frac{21.6\,l\,I}{u} \text{ circular mils}$$

The values of l and u can be determined as explained in Art. **130.** The value of I is found by adding together the inputs, in watts, required by all apparatus supplied by the given feeder or main, dividing this total by the voltage at the apparatus, and taking the proper percentage of the quotient so obtained. If the amperes input of a motor cannot otherwise be determined, the value can be found by dividing the output, in watts, by the efficiency and the rated voltage. Average efficiencies of direct-current motors are given in Table IV.

TABLE IV

AVERAGE EFFICIENCIES OF 110- AND 220-VOLT DIRECT-CURRENT MOTORS

Size of Motor Horsepower	Efficiency Per Cent.
1 to 5	80
5 to 20	85
25 to 100	90
150 to 200	93

Motor leads must be designed to carry a current at least 25 per cent. greater than that for which the motor is rated.

132. Having found the number of circular mils required, a wire table should be consulted to find the size of wire or cable having a cross-sectional area next greater than or very nearly equal to the calculated value. The National Electric Code table of carrying capacities should then be consulted to ascertain if the size chosen has the specified carrying capacity; if not, a conductor large enough to carry the maximum possible load on the given main or feeder must be selected.

If the size of the conductor, in circular mils a, is known, the voltage drop for a given current I amperes is

$$u = \frac{21.6\, l\, I}{a} \qquad (1)$$

The current that can be carried by a conductor a circular mils in cross-sectional area with a drop of u volts is

$$I = \frac{a\, u}{21.6\, l} \text{ amperes} \qquad (2)$$

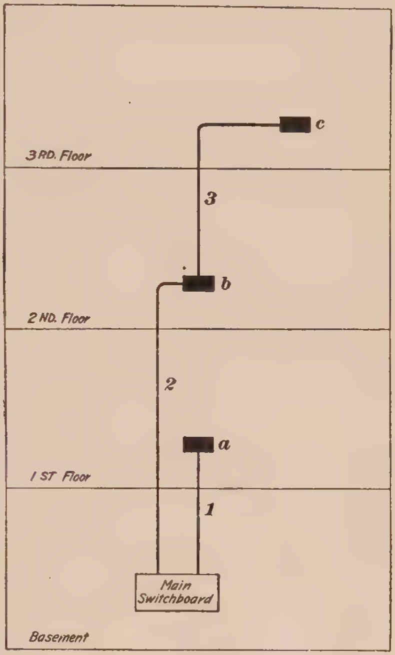


FIG. 91

133. Three-Wire Circuits.—Branches from a three-wire direct-current feeder or main are usually so arranged that the load on the feeder or main is nearly balanced and calculations are carried out on this basis. The formulas of Arts. **131** and **132** are applied by treating the balanced three-wire system as a two-wire system with a voltage equal to that between the outside wires of the three-wire system. The size of wire for the neutral should be equal to that determined by the calculations for the outside wires.

EXAMPLE 1.—In Fig. 91, cut-out panels *a*, *b*, and *c* are supplied by feeders *1* and *2* and main *3* of a direct-current, two-wire system. The conditions of the installation are arranged as follows:

	LENGTH FEET	LOAD AMPERES	ALLOWABLE DROP VOLTS
Feeders *1*.	50	60	2.0
Feeders *2*.	110	50	2.0
Main *3*.	30	20	.5

The 50-ampere load on feeder *2* includes the load of 20 amperes on main *3*. Find the sizes of rubber-covered conductors to be used for each feeder and the main.

SOLUTION.—Applying the formula in Art. **131**, the cross-sectional area of feeder *1*, to give the required drop, should be $a = \frac{21.6 \times 50 \times 60}{2} = 32{,}400$ cir. mils. On a basis of voltage drop, No. 5 B. & S. wire would be chosen, but, by Table II, *Electric Wiring*, Part 1, the carrying capacity of No. 5 wire is only 55 amp. and No. 4 or larger should be used for feeder *1*, to comply with the National Electric Code rules. Ans.

To give a drop of 2 volts, feeder *2* should have a cross-sectional area of $a = \frac{21.6 \times 110 \times 50}{2} = 59{,}400$ cir. mils. No. 2 B. & S. wire, with a cross-sectional area of 66,370 cir. mils. and a carrying capacity of 90 amp. should be used. Ans.

For a drop of .5 volts under the given conditions, main *3* should have a cross-sectional area of $a = \frac{21.6 \times 30 \times 20}{.5} = 25{,}920$ cir. mils. The next larger conductor is No. 6 B. & S., with a cross-sectional area of 26,250 cir. mils and a carrying capacity of 50 amp.; this should be used. Ans.

EXAMPLE 2.—Fifty, 60-watt, 110-volt, incandescent lamps are connected to a panel board located 80 feet from the main switchboard; 80 per cent. of the lamps will probably be in use at one time. The panel is supplied by a two-wire, direct-current feeder direct from the switchboard. A total drop of 3 per cent. between the switchboard and the lamps is allowable, 1 per cent. in the branch circuits and 2 per cent. in the feeder. What size of rubber-covered wire should be used for the feeder?

SOLUTION.—Fifty, 60-watt, 110-volt lamps require $\frac{50 \times 60}{110} = 27.3$ amp., 80 per cent. of which is $.8 \times 27.3 = 21.8$, say 22, amp. The allowable drop in the feeder is 2 per cent. of 110, or $.02 \times 110 = 2.2$ volts. Applying the formula in Art. **131**, the feeder-wire must have a cross-sectional area of $a = \frac{21.6 \times 80 \times 22}{2.2} = 17{,}280$ cir. mils. No. 8 B. & S. gauge wire, with a carrying capacity of 35 amp., can safely be used, though its cross-sectional area, 16,510 cir. mils, is slightly smaller than the computed value. Ans.

If any allowance is to be made for a future increase in load, larger wire should be selected.

EXAMPLE 3.—Other conditions remaining the same as in example 2, what size of feed-wires would be required if the lamps were connected on the 110—220-volt, three-wire system?

SOLUTION.—In this case the lamps would require only $\frac{50\times60}{220}=13.6$ amps. maximum current, 80 per cent. of which is 10.9, say 11 amp. The allowable drop is 2 per cent. of 220, or 4.4 volts. Then, $a=\frac{21.6\times80\times11}{4.4}=4{,}320$ cir. mils will be the proper cross-sectional area, and No. 14 wire (4,107 cir. mils), with a carrying capacity of 15 amps., may be used, though No. 12 wire would be preferable. Ans.

EXAMPLE 4.—If No. 6 B. & S. wire is used for the feeder in example 2, what will be the actual drop in the feeder-conductors?

SOLUTION.—Substituting in formula **1**, Art. **132**, the drop will be

$$u=\frac{21.6\times80\times22}{26{,}250}=1.4 \text{ volts.} \quad \text{Ans.}$$

EXAMPLE 5.—How many 40-watt, 110-volt lamps can be connected to a panel board supplied by direct-current through a 75-foot feeder of No. 2 B. & S. rubber-covered wire if the allowable drop in the feeder is 1.5 volts?

SOLUTION.—According to wire tables, the cross-sectional area of No. 2 wire is 66,370 cir. mils. Applying formula **2**, Art. **132**, the current that can be carried by the feeder with a drop of $u=1.5$ volts is $I=\frac{66{,}370\times1.5}{21.6\times75}$ $=61.5$ amp., which is 28.5 amp. less than the allowable carrying capacity of No. 2 rubber-covered wire. Each lamp requires $\frac{40}{110}=.36$ amp.; therefore, 61.5 amp. will supply $\frac{61.5}{.36}=170$ lamps. Ans.

If carrying capacity alone were considered, $\frac{90}{.36}=250$, 40-watt, 110-volt lamps could be connected to the panel.

EXAMPLE 6.—A 25-horsepower, 220-volt, direct-current motor is to be supplied with electric energy through a 60-foot, two-wire feeder in which the permissible voltage drop is 5 per cent. What size slow-burning, weather-proof conductors should be used for the feeder?

SOLUTION.—By Table IV, the efficiency of the motor can be taken as 90 per cent., or .9. The watts input to the motor at normal load is $\frac{25\times746}{.9}$;

allowing 25 per cent. for overload (see Art. **131**), the maximum current input may be $\frac{25\times746\times1.25}{.9\times220}=117.7$, say 118 amp. By the formula in Art. **131**, the cross-sectional area of the feeder-conductors should be $a=\frac{21.6\times60\times118}{.05\times220}=13{,}902$ cir. mils. The use of No. 8 wire, 16,510 cir. mils, would keep the voltage drop well within the limit; but to comply with the National Electric Code specifications, a No. 2 wire, with a carrying capacity of 125 amp., must be used. Ans.

ALTERNATING-CURRENT CALCULATIONS

134. In calculating the sizes of conductors for alternating current, allowance must be made for the power factor of the load. In most interior-wiring installations, the reactance, skin effect, and mutual induction in the wiring are negligible because of the arrangement and dimensions of the conductors. The formulas for alternating-current calculations can be conveniently written as follows:

$$a=\frac{K\,l\,I}{u} \qquad (1)$$

$$u=\frac{K\,l\,I}{a} \qquad (2)$$

$$I=\frac{a\,u}{K\,l} \qquad (3)$$

TABLE V

VALUES OF CONSTANT *K* IN ALTERNATING-CURRENT FORMULAS

System	Power Factors				
	1.00	.95	.90	.85	.80
	Values of *K*				
Single-phase	21.6	24.0	27.0	30	34.0
Two-phase, four-wire . . .	21.6	24.0	27.0	30	34.0
Three-phase, three-wire .	18.7	20.8	23.4	26	29.4

for which the value of K is selected from Table V. The quantity I is the current per wire. The remaining symbols have the same significance as in the direct-current formulas of Arts. **131** and **132.**

The value of the current per wire for single-phase systems is $I = \frac{p}{n\,E}$; for two-phase four-wire systems, $I = \frac{p}{2\,n\,E}$; and for three-phase three-wire systems, $I = \frac{p}{1.73\,n\,E}$, in all of which p is the load in watts, n the power factor of the load, and E

TABLE VI

APPROXIMATE AMPERES PER TERMINAL FOR ALTERNATING-CURRENT INDUCTION MOTORS

Horsepower of Motor	110-Volt		220-Volt		440-Volt	
	2-Phase	3-Phase	2-Phase	3-Phase	2-Phase	3-Phase
.5	3.3	3.7	1.7	1.8	.9	1.0
1.0	6.0	6.5	3.0	3.2	1.5	1.6
2.0	10.5	12.0	5.0	6.0	2.6	3.0
3.0	15.0	17.0	7.5	9.0	3.8	4.5
5.0	27.0	30.0	13.0	15.0	6.5	7.5
7.5			20.0	22.0	10.0	11.0
10.0			25.0	29.0	12.5	14.0
15.0			35.0	41.0	18.0	20.0
20.0			48.0	55.0	24.0	27.0
25.0			54.0	62.0	27.0	31.0
30.0			70.0	81.0	35.0	40.0
40.0			95.0	109.0	47.0	54.0
50.0			110.0	127.0	55.0	64.0
75.0			165.0	192.0	83.0	96.0
100.0			215.0	248.0	108.0	124.0
150.0			320.0	366.0	160.0	183.0
200.0			410.0	475.0	205.0	237.0
250.0			510.0	590.0	250.0	290.0
300.0			600.0	700.0	300.0	350.0

the voltage at the load. In each case the load on a polyphase system is assumed to be balanced. When the power factor n cannot be accurately determined, average values of 1 for incandescent lamps only, .85 for a mixed load of lamps and motors, and .80 for motors only can be taken in ordinary practice.

135. The full-load ampere rating per terminal of an alternating-current motor is usually given on the name plate; if not, the value can be obtained from Table VI or by the formulas

$$I = \frac{746 \text{ H. P.}}{e\,n\,E} \text{ for single-phase machines,}$$

$$I = \frac{746 \text{ H. P.}}{2\,e\,n\,E} \text{ for two-phase machines, and}$$

$$I = \frac{746 \text{ H. P.}}{1.73\,e\,n\,E} \text{ for three-phase machines,}$$

in all of which expressions H. P. represents output in horsepower, e the efficiency, and the other letters the same as in preceding articles. Average values of efficiency are given in Table VII. To adapt Table VI to single-phase motors multiply the current values for two-phase motors by 2. The values obtained by the use of Table VI or the formulas are normal full-load currents, and at least 25 per cent. additional current should be allowed for starting and overload; under some conditions, an allowance of as much as 50 per cent. must be made.

TABLE VII

AVERAGE EFFICIENCIES OF POLYPHASE INDUCTION MOTORS

Horsepower	Efficiency Per Cent.
1	80
5	85
20	88
300	93

136. The current used in determining the size of leads for varying speed alternating-current motors depends on the class of service and is specified for each class in the National Electric Code. The term *varying speed motors* here means motors in which the speed varies automatically with the load, decreasing when the load increases, and vice versa. It does not mean motors in which the speed is varied by the use of different windings or groupings of windings, or motors in which the speed is varied by external means, and in which the speed remains practically constant after each adjustment.

EXAMPLE 1.—A 20-horsepower, 220-volt, three-phase, induction motor driving a pump is located 40 feet from the main switchboard. Allowing a drop of 3 volts, what size of rubber-covered feed-wire should be used?

SOLUTION.—According to Table VI, a 20-H.-P., 200-volt, three-phase motor takes 55 amp. per terminal at normal load. Assuming 50 per cent. above normal for starting and overload, the value of I, formula **1**, Art. **134**, becomes $55\times1.50=82.5$ amp. Since the system is three-phase and the power factor of a motor load can be taken as .80, the value of K, from Table V, is 29.4. Substituting, $a=\frac{29.4\times40\times82.5}{3}=32{,}340$ cir. mils. A No. 5 B. & S. gauge wire, 33,100 cir. mils, will keep the voltage drop within the limit, but to carry 82.5 amp. a No. 2 wire will be required. Ans.

EXAMPLE 2.—A 220-volt, three-phase, induction motor rated at 62 amperes per terminal is to be installed at a distance of 80 feet from the switchboard. The power factor is approximately .85. What will be the voltage drop in a feeder of No. 2 B. & S. rubber-covered wire at 50 per cent. overload?

SOLUTION.—At 50-per cent. overload, the motor will take $62\times1.50=93$ amp. per terminal, which is the value for I, formula **2**, Art. **134**. By Table V, the value of K is 26. By a wire table, the value of a is 66,370 cir. mils. The distance l is given in the problem as 80 ft. Substituting,

$$u=\frac{26\times80\times93}{66{,}370}=2.9 \text{ volts. Ans.}$$

EXAMPLE 3.—How many 50-watt, 110-volt, incandescent lamps can be carried by a two-phase, four-wire feeder of No. 0 wire, 90 feet long with a drop of 2 volts, assuming the load to be balanced?

SOLUTION.—Use formula **3**, Art. **134**, to find the permissible current. The cross-sectional area a of No. 0 wire is 105,500 cir. mils. The allowable drop u is 2 volts. The power factor for lamps is 1 and the constant K, Table V, is 21.6. The length l of the feeder is 90 ft. Substituting, $I=\frac{105{,}500\times2}{21.6\times90}=109$ amp., will give a drop of 2 volts. The current limiting factor in this problem is the 2-volt circuit drop; therefore, since each lamp requires $\frac{50}{110}$ amp., each phase of the feeder can carry $\frac{109\times110}{50}$ lamps, and both phases together can carry $\frac{2\times109\times110}{50}=480$ lamps. Ans.

ESTIMATES

137. Estimates of the costs of proposed wiring jobs are based chiefly on experience; most contractors keep detailed costs analyses of previously executed contracts, and estimates on proposed work are based on this cost data, due allowances, of course, being made for different items, prices, and conditions.

The cost of wiring is made up of the cost of material, labor, sundries, and overhead expenses. The last named consists of items such as office expense, depreciation of tools, interest on capital, rent, etc. that cannot be charged to any one job, but are divided among various contracts, usually in proportion to the labor costs.

138. The estimator obtains data on a proposed job from the plans and specifications, or, if these lack details, from his own layouts. If the job is a large one, each circuit is analyzed by itself and the quantities of various materials, such as number of outlets, number of switches, number of receptacles, feet of conduit, feet of wire, etc., are recorded, each kind in a separate column, on a *circuit-detail sheet*. When every circuit has been analyzed in this manner, the amounts in the various columns are added together and the total quantity of each item in the contract thus obtained. Items like panel boards and cabinets are handled separately; sometimes special panel boards are required, in which case quotations must be obtained from manufacturers.

An *analysis sheet* is then prepared showing the items, the total quantity of each, the unit costs for labor and material, separately and combined, and the total costs. The prices of materials are obtained from manufacturers' and jobbers' lists and the prices of labor from the cost data of previous jobs. To the cost of the items that are a part of the installation there must be added the estimated cost of temporary work, such as the erection of scaffolds, and of sundries, such as cartage and carfare; then by adding a percentage to cover contingencies and overhead expenses and a percentage of profit, the amount of the contractor's bid is obtained.

In making estimates, care must be taken to consider the construction of the building, which has great influence on the cost of labor. The estimator should have in mind a tentative plan for carrying out the work on which he is preparing a bid.

139. Sometimes a contractor is asked to bid on a small job without plans, his knowledge of the job being obtained by an inspection of the building. In such cases the bid is usually made on a basis of a certain cost per outlet. Another rough method of estimating is to figure the number of lamps, averaging ten to a circuit, to obtain the number of circuits, then assuming a certain average length per circuit. These methods of estimating are unsafe unless the estimator has had considerable experience in work of certain classes.